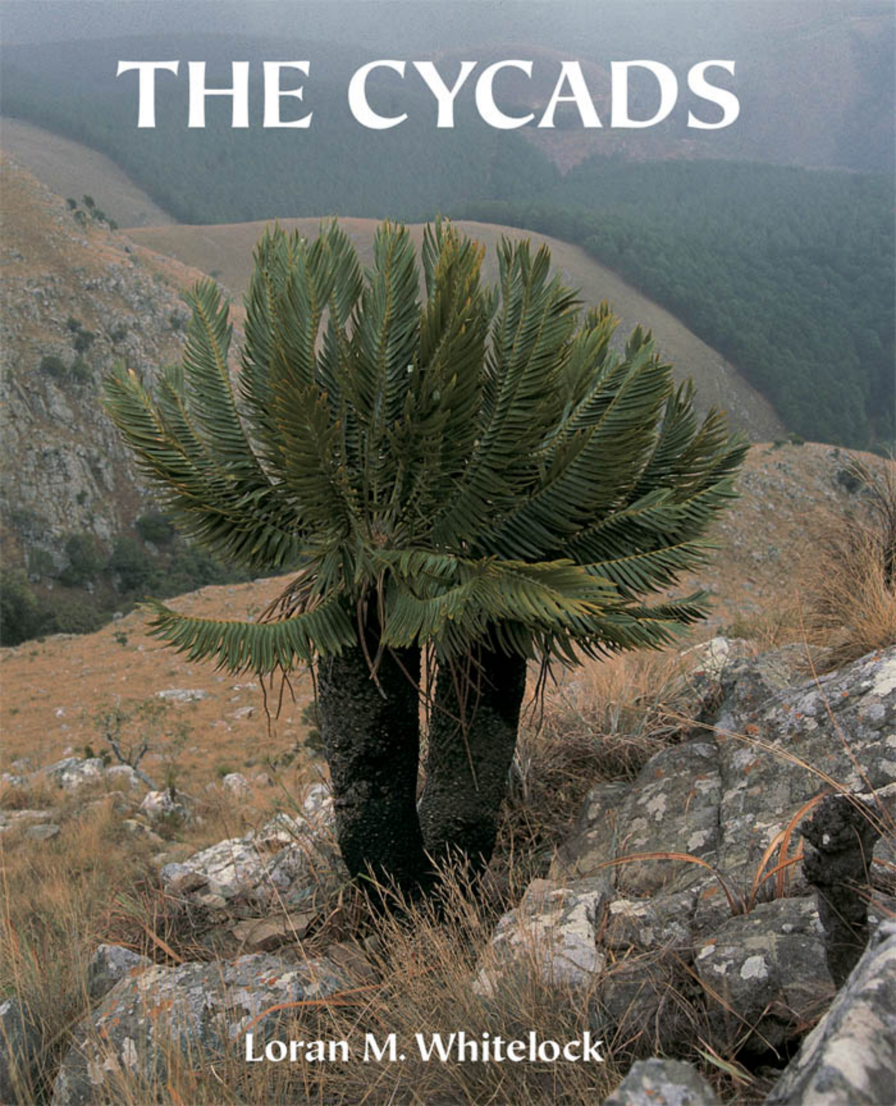
THE CYCADS



Loran M. Whitelock

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TIMBER PRESS
Portland, Oregon

All drawings by Geoff Stein. Half-title page: *Encephalartos longifolius*; frontispiece: left to right, front row, *E. concinnus, E. horridus, Stangeria eriopus, E. caffer,* middle row, *Zamia furfuracea, Macrozamia moorei, Cycas micholitzii,* back row, *C. chamberlainii, E. woodii*

Published in 2002 by
Timber Press, Inc.
The Haseltine Building
133 S.W. Second Avenue, Suite 450
Portland, Oregon 97204, U.S.A.

Printed in Hong Kong

Library of Congress Cataloging-in-Publication Data

Whitelock, Loran M.
The Cycads / Loran M. Whitelock.
p. cm
Includes bibliographical references (p.).
ISBN 0-88192-522-5
1. Cycads. I. Title

SB413.C88 W46 2002
635.9'359—dc21

2001035809

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Color plates follow pages 48 and 80

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Preface

In *The Cycads* I have attempted to produce a reliable reference book for both botanist and gardener by bringing together all the information that is available on each genus and species. There are few other groups of plants, with the possible exception of palms, that can rival cycads for variety of foliage, size, and general habit. Cycads are very ornamental with their palmlike structure and their variety of leaf shapes, sizes, and colors. They have not, however, been commonly used in landscape planting. The one exception is the Japanese *Cycas revoluta,* sago palm, which is probably the most widely grown cycad in the world. Cycads are tough and durable plants, some suited to full sun whereas others need shady conditions. The shade-loving species make fine houseplants, and both sun and shade plants are exceptional as potted specimens.

All cycads are endangered and for this reason are regulated by the Convention on the International Trade of Endangered Species of Fauna and Flora, commonly referred to as CITES. In more recent years, some countries have allowed artificially propagated cycads to be shipped in increasing numbers, and this has made them more readily available to those who wish to cultivate them. Cycads are also being propagated outside their native countries by hobbyists and nurseries in ever larger numbers, and this too has increased the availability of some rare species. A large share of the artificial propagation of cycads is being carried out in the United States to supply the demand of collectors. As this trend continues we shall see more of the uncommon and rare species become available at lower prices.

At present, as in the past, there is confusion regarding the true identity of some cycads. This confusion has caused incorrect names to be applied to some populations of cycads. Much of this confusion applies to cycads in the New World Tropics and the South Pacific and will require considerable fieldwork, collection, and study for clarification. This by no means implies that the cycads of Africa, Australia, and the Far East are in perfect taxonomic order. On the contrary, there remain many taxonomic problems to be studied in those areas as well.

The primary difficulty experienced in the cultivation of cycads has been their limited availability. There are about 289 species in 11 genera, but no more than 8–10 species of 5 genera are common horticulturally, largely grown in California and Florida in the United States. Since the 1980s, the popularity of cycads has grown at a remarkable rate. That all cycads are now classified as endangered has fueled interest in them and their popularity. Research has led to the discovery of many newly known species and the availability of a broader range of species horticulturally. Many more cycads can and will be grown as they become better known and more available in the nursery trade. As an encouragement to their increased use, an appendix has been provided here, Cycads for Particular Purposes.

The newfound popularity of cycads is the result of a proliferation of collections rather than a widespread acceptance of cycads in landscaping. Once the better horticultural species become available in larger sizes, they will doubtless become more widely used in gardening and landscaping. That has happened with many palm species that are now more widely available and grown more commonly. Cycads are superior to palms in that they are slower growing and therefore do not outgrow their landscape as palms do. Cycads are also far better for smaller gardens for the same reason.

The average nursery does not normally stock a large selection of cycads but is confined to growing only the one or two most popular species. But there are numerous private collections that contain a hundred or more species, ranging in size from seedlings to tall plants. These cycads have been acquired through searching for plants available from importers, rare plant nurseries, botanical gardens, and exchanges with other collectors, often in other countries. Formerly, it must be admitted, numbers of these plants were gathered from the wild, a practice no longer to be condoned because of the rarity of cycads in nature. Some of these collections have grown large enough that their owners can produce viable seed from them. Those collectors with the interest and energy to propagate their plants are to be commended.

It is my hope that *The Cycads* will be of assistance to botanists and other researchers, and collectors and growers, and that it will add to the ranks of those interested in cycads. It is these people who will be burdened with the responsibility of conserving the world's remaining cycad populations.

Acknowledgments

The Cycads would not have been possible without the assistance of many friends, researchers, and enthusiasts from around the world. Their generous contributions, over many years, of information and photographs have enabled me to realize my dream of producing a comprehensive, well-illustrated review of the cycads. It is impossible to name them all but I attempt to include those who made major contributions toward this publication. My heartfelt gratitude and thanks go to all.

The first person I must acknowledge is my wife, Eva. Without her understanding, assistance, and moral support, this book could not have been written. She has traveled with me, often under difficult circumstances, to Africa, Australia, China, Taiwan, the Philippines, Mexico, and the Bahamas. She has tolerated with grace and understanding both my numerous extended absences while I was on cycad expeditions, and my seemingly endless hours of researching and writing this book. She has been irreplaceable.

In particular, I thank the numerous people with whom I have traveled in search of cycad habitats. They have been, without exception, tireless and enjoyable traveling companions. Although we were originally brought together because of our mutual interest in cycads, friendships were formed that in some cases have lasted almost 40 years.

My travels in Africa were made successful with the help of the following people: Bruce and Joan Bursey, Kei Road, Eastern Cape, South Africa; Johan Hurter, Lowveld National Botanical Garden, Nelspruit, South Africa; Derrick Lawson, Emden Pienaar, and Ian Turner, Harare, Zimbabwe; Lionel Morse and George Myers, White River, Transvaal, South Africa; Louis Naude, Pretoria, South Africa; Dan Roux, Potgietersrust, Transvaal, South Africa; and Ernest Thorp and Ken Wyman, former curators, Durban Botanic Gardens, South Africa.

In Australia my travels were assisted by Monty Anderson and George Brown, Darwin, Northern Territory; Cheryl Basic, Brisbane, Queensland; Pat and David Coutts, Townsville, Queensland; Greg Durney, Sydney, New South Wales; Ken Hill and Leonie Stanberg, Royal Botanic Gardens, Sydney, N.S.W.; Rod Horner, Alice Springs, Northern Territory; Paul Kennedy, Engadine, N.S.W.; Ed Moore, San Diego, California; Joe Perner, Katherine, Northern Territory; Craig Thompson, Sylvania, N.S.W.; Marie Trefeu, Wacol, Queensland; and Stan and Jane Walkley, Burpengary, Queensland.

In Mexico and Central and South America my traveling companions were Bob Alonso, Fort Myers, Florida; Horace and Mary Anderson, Leucadia, California; Pat and David Coutts, Townsville, Queensland, Australia; Gregg Hamann, El Cajon, California; Verne Magnuson, Rancho Santa Fe, California; George Proctor, San Juan, Puerto Rico; the late Jack Roth, formerly of Carlsbad, California; Minoru Shibata, Cali, Colombia; and Allen Wittington, Florida. My special thanks go to Edward Carlson of Santa Ana, California, who was my companion on numerous trips to Mexico and Panama. Ed's friendship, assistance, and good humor made these trips not only successful but also very enjoyable.

In Asia my travels were assisted by Francis Ching, former director of the Los Angeles State and County Arboretum, Arcadia, California; Kampon Tansacha, director, and P. Vatcharakorn of Nong Nooch Tropical Garden, Thailand; and Stan Walkley of Burpengary, Queensland, Australia.

Photographs and data were generously contributed by the following: Russell Adams, Gainesville, Florida; Rae Anderson, Sierra Madre, California; Rodrigo Bernal, Universidad Nacional de Colombia, Bogotá; Libby Besse, Sarasota, Florida; the late Maria Boggs, formerly of Mount Molloy, Queensland, Australia; William M. Boyd,

Steve P. Fourie, and Tommie Steyn, previously all from the Transvaal Chief Directorate of Nature and Environmental Conservation, Nelspruit, South Africa; Terry Brabham, Costa Mesa, California; Gary J. Breckon, University of Puerto Rico, Mayaguez; the late Bruce Bursey, Lowlands Nursery, Eastern Cape, South Africa; Prof. George C. Carroll, University of Oregon, Eugene; Curt Butterfield, Port Douglas, Queensland, Australia; Jeffrey Chemnick, Santa Barbara, California; Dr. Richard N. Cirino, Costa Mesa, California; Dr. Mark Cua, Manila, Philippines; Dr. Calaway Dodson, Río Pelenque Science Center, Ecuador; Dr. John Donaldson, National Botanical Institute, Cape Town, South Africa; the late Dr. Robert Allen Dyer, former director of the Botanical Research Institute, Pretoria, South Africa; Bernard Fischer, Innesdale, South Africa; Peter Fletcher, Santa Barbara, California; Dr. James P. Folsom, director, and Kathy Musial, Huntington Botanical Gardens, San Marino, California; Len Forrester, Cathcart, Eastern Cape, South Africa; Dr. Paul I. Forster, Queensland Herbarium, Brisbane, Australia; Kenneth C. Foster, Pahoa, Hawaii; Bill Gaynor, Perth, Western Australia; Danny Gooden, Lidcombe, New South Wales, Australia; Dr. Timothy Gregory, Hillsborough, California; Ramachandhren Haresh, Madurai, India; the late Denis Heenan, formerly of Piggs Peak, Swaziland; Peter Heibloem, Eudlo Cycad Gardens, Nambour, Queensland, Australia; Andrew Henderson and Dr. Dennis W. Stevenson, New York Botanical Garden, Bronx; Dr. Kenneth D. Hill, Royal Botanic Gardens, Sydney, Australia; Donald R. Hodel, Lakewood, California; Dale Holton, Lake Worth, Florida; Petrus Johannes (Johan) Hendrick Hurter, Lowveld National Botanical Garden, Nelspruit, South Africa; Charles Hubbuch, Stanley Kiem, former superintendent, and William Tang, Dr. Scott Zona, and formerly, Dr. Knut Norstog, of the Fairchild Tropical Garden, Miami, Florida; Alfred Lau, Punta Gorda, Belize; John J. Lavranos, Goulandris Natural History Museum, Greece; Anders Lindstrom, Nong Nooch Tropical Garden, Thailand; Dr. Richard Litz, University of Florida, Homestead; Irvin McDaniel, Fallbrook, California; Cameron McMaster, Stutterheim, Eastern Cape, South Africa; Dr. Thomas E. Marler, University of Guam, Mangilao; Dr. Aldo Moretti, University of Naples, Italy; Masayuki Nako, Okinawa, Japan; Mukundan Partha Sarathy, Chennai, Tamil Nadu, India; the late Raymond Munch, Rusape, Zimbabwe; Dr. Li Nan and Dr. Dingyue Wang, Fairy Lake Botanical Garden, Shenzhen, Guangdong, China; Larry Noblick and Dr. Terence Walters, managing director, Montgomery Botanical Center, Miami, Florida; Dr. Roy Osborne, formerly of the University of Natal, Durban, South Africa; Joe Perner, Katherine, Northern Territory, Australia; Michael Perry, Englewood, Florida; John Provine, former superintendent, and Earl Ross, formerly of the Arboretum of Los Angeles County, Arcadia, California; Prof. Narayana Rao, Sri Venkatesvara University, Andhra Pradesh, India; Dr. John Rees, Los Angeles State College, Los Angeles, California; Johan A. van Rensburg, Klerksdorp, South Africa; Bart Schutzman, University of Florida, Gainesville; Jean-Pierre Sclavo, Nice, France; Greg Seaman, Townsville, Queensland, Australia; Dan Shook, Kiliuea, Hawaii; Dr. Mark Smith, Rancho Santa Fe, California; Lynn Stewart, North Ryde, N.S.W., Australia; Dr. Steven Timbrook, director, Ganna Walska Lotusland, Montecito, California; Hajime Tomiyama, Yomutan-son Okinawa, Japan; Ian Turner, Harare, Zimbabwe; Dr. Piet Vorster, University of Stellenbosch, Matieland, Western Cape, South Africa; Guy Wrinkle, North Hollywood, California; Dr. Si Lin Yang, Southwest Agricultural University, Chongqing, Sichuan, China; Clayton York, Valdora, Queensland, Australia.

Geoff Stein is the artist responsible for the fine drawings throughout the book.

Library research was efficiently carried out by Joan DeFato, librarian at the Arboretum of Los Angeles County, Arcadia, California, and Danielle Rudeen of the Huntington Library and Botanical Gardens, San Marino, California.

Terry Brabham, Nora Martinez, and Eva Whitelock generously aided in the preparation of the manuscript, and Terry Brabham, Dick Spears, Dan Smith, Roger Walsh, and Daniel Pedderson provided assistance with computer programs and problems.

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CHAPTER ONE

Cycad Distribution Past and Present

The only hard evidence we have for the prehistoric distribution of the cycads is fossils. Cycad fossils have been discovered on every continent as well as some of the larger islands. These fossils have been uncovered in several areas where current climatic conditions are inhospitable to cycads, such as Alaska, Antarctica, and Russia (Plates 1–3). In the past, it was thought that these fossils indicated that at one time Earth had a warm, humid climate over its entire surface. This period of geologic history was to become known as the Age of Cycads.

More recently, there have developed two major theories on what caused the present distribution of cycads. The geologic evidence used to define these two theories is circumstantial at best, only guesses based on the evidence available. The truth may consist of a combination of the ideas set forth in these two theories, and we will never know with certainty exactly what happened to the Earth over the past 200 million years.

The first theory is that of a major worldwide climatic change. Some scientists believe this climatic change was brought about by an asteroid striking the Earth, with the massive amount of dust created by the impact absorbing the sun's rays for many years, causing the Earth to cool. It is believed that this cooling of the atmosphere caused the formation of the polar ice caps, which in turn caused colder climatic conditions to move toward the equator. These colder conditions were thought to be responsible for the extinction of many plant and animal species, such as the dinosaurs. This scenario could explain why cycads are restricted to the Tropics and sub-Tropics.

The second theory, one that has gained widespread acceptance in the scientific community, is that of continental drift. Continental drift is based on the concept that the continents have not always been positioned as they are today. In 1912 Alfred Wegener, a geologist and meteorologist, proposed that at the beginning of the Mesozoic era the landmass of the Earth was in the form of a single supercontinent, which he named Pangaea. He also proposed that this supercontinent began to divide about 150 million years ago into two large continents, Gondwana in the Southern Hemisphere and Laurasia in the Northern Hemisphere. These two landmasses are thought to have subsequently divided and separated into our present continents.

Whatever the true causal factors of the present distribution of cycads, we know that they are now, and have been in past ages, basically tropical plants. If we mark all existing cycads on a world map, we find that they generally occur between the tropics of Cancer and Capricorn, or more exactly, between 30° north latitude and 35° south latitude. It is interesting to note that the majority of cycad species occur in the sub-Tropics, with only a handful of species in equatorial habitats. The limited number of species found in equatorial habitats generally occur at higher elevations, where air temperatures and humidity are usually lower. Those species found in low-elevation rain forest habitats, where the temperatures and humidity are high, usually belong to the genera *Zamia* and *Chigua.* There are few cycads that can tolerate extended periods of frost or freezing, but a number of species (*Encephalartos ghellinckii, E. cycadifolius,* and *Macrozamia occidua,* to name a few) have adapted to habitats that experience freezing weather and moderate snowfall annually.

In the Western Hemisphere there are five genera of cycads, *Ceratozamia, Chigua, Dioon, Microcycas,* and *Zamia.*

Four occur north of the equator, with only *Zamia* extending south of the equator. Two of these genera are restricted to a single country, with *Microcycas* occurring only in Cuba, *Chigua* in Colombia.

In the Eastern Hemisphere there are six genera, *Bowenia, Cycas, Encephalartos, Lepidozamia, Macrozamia,* and *Stangeria.* All occur south of the equator with the exceptions of *Cycas* and *Encephalartos,* which have some species ranging north of the equator. Of these six genera, four are restricted to single countries, with *Bowenia, Lepidozamia,* and *Macrozamia* occurring only in Australia, and *Stangeria* in South Africa.

Factors Limiting Distribution

Cycad habitats, besides being generally frost-free, usually experience summer rainfall and cool, dry winters. Generally, cycads do not occur naturally in Mediterranean (winter rainfall) climates, seeming to prefer rain during the hot summer months. In cultivation, cycads adjust to winter rainfall without difficulty. Rainfall must be at least 350 mm (14 in) annually for cycads to survive. Some exceptional tropical habitats may have rainfall in excess of 5500 mm (220 in) annually. Soils are generally sand or sand-based gravels, mixed with smaller amounts of clay and humus. The most important soil requirement is that it drain rapidly and be somewhat aerated, though in Colombia, *Zamia amplifolia, Z. chigua,* and *Z. roezlii* often grow in wet, heavy soils best described as muck. Rain forest cycads often grow in almost pure leaf mold between limestone rocks.

Cycads generally have a low tolerance for salt, but *Zamia roezlii* has adjusted to growing in coastal marshes that are inundated at high tide with seawater. *Zamia furfuracea* in Veracruz, Mexico, grows on coastal sand dunes almost down to the high-tide mark. In this location, the prevailing winds off the Gulf of Mexico continuously carry salt spray over almost the entire habitat.

Although cycads have a number of factors limiting their distribution and growth, they have been able in many cases to adjust to adverse conditions. This ability to adapt to varying conditions has allowed them to survive at elevations from sea level to more than 2500 m (8000 ft), in climates from sea-level Tropics to low- and high-elevation desert, and in habitats from cloud forest to montane forest.

CHAPTER TWO

Classification of the Cycads

The order Cycadales, commonly referred to as the cycads, comprises the most primitive of the surviving gymnosperms (seed-bearing plants whose seeds are not in fruits) whose fossil history can be traced back more than 200 million years. Because their seeds are exposed on sporophylls, which are arranged spirally into a cone and not enclosed in an ovary like those of flowering plants, cycads are included among the other coniferous plants such as pines and ginkgoes.

In their early botanical history, all the living cycad genera were placed in the family Cycadaceae. This changed in 1959 when the Australian botanist Lawrence A. S. Johnson discerned that three distinct groups of cycad genera would be better placed into separate families, the Cycadaceae, Stangeriaceae, and Zamiaceae.

More recently, Dennis W. Stevenson of the New York Botanical Garden has carried out a series of cladistic analyses of all living cycads. His analysis in 1992 used 52 characters to compare the cycads. The results of his study are shown in the accompanying classification tabulation. Additional research into the relationships between the various cycad genera is still underway, with evidence suggesting that one or two additional families may be proposed.

Cycad Names

Common Names versus Scientific Names

People of all countries use common names for their plants and animals. These names are usually learned in childhood and are passed on from generation to generation. A common name may or may not represent a species in the botanical sense and can encompass a larger group such as palms or oaks. In any event the same name

Order	Suborders	Families	Subfamilies	Tribes	Subtribes	Genera
Cycadales	Cycadineae	Cycadaceae				*Cycas*
	Zamiineae	Stangeriaceae	Stangerioideae			*Stangeria*
			Bowenioideae			*Bowenia*
		Zamiaceae	Zamioideae	Zamieae	Zamiinae	*Zamia*
						Chigua
					Microcycadinae	*Microcycas*
				Ceratozamieae		*Ceratozamia*
			Encephalartoideae	Encephalarteae	Encephalartinae	*Encephalartos*
					Macrozamiinae	*Macrozamia*
						Lepidozamia
				Diooeae		*Dioon*

is applied to all plants supposed to be of the same kind. To narrow the selection, an adjective may be added as in coconut palm or live oak.

The great disadvantage of common names is that they vary. Common names for a particular plant with a wide geographic range may vary from country to country, language to language, or even in different areas of the same country. It is not uncommon for plants as botanically different as palms and cycads to have the same common name. This is so because palms and cycads resemble each other in form and are therefore considered by many people to be the same. In many areas of Mexico the smaller cycads are called *palmita,* little palm. The Mexican cycad *Dioon spinulosum* is called *palma de chicle,* gum palm, as its gum or sap is used for chewing. While I was looking for cycads in Mexico I would ask local Indians about the location of plants. When shown a photograph of a cycad they would say they knew the plant and could take me there. Almost without fail, I would be led to a palm!

The imprecision and ambiguity of common names are avoided with scientific names. The basic scientific name is a binomial, a name consisting of two parts. Each species of plant or animal is given a name consisting of the name of the genus followed by a specific name or epithet. The genus name is a noun, and the specific epithet is a modifying adjective that indicates which species of the genus is being considered. The genus name usually suggests some character of the plant, as in *Dioon,* which means two eggs and refers to the two seeds attached to each female sporophyll. Names of species are commonly descriptive, as in *Encephalartos trispinosus,* in which the epithet refers to the three spines on each leaflet, or *D. edule,* in which the epithet refers to the plant's edibility. Often, the epithet is taken from the name of a person, as in *E. heenanii,* after Denis Heenan, who discovered this cycad. Names of places may also be used, as in *E. lebomboensis,* in which the epithet refers to this cycad's area of occurrence, the Lebombo Mountains in South Africa and Swaziland. Epithets are printed with a lowercase letter even when derived from a proper name. When the name of a genus is used as a common name it is lowercased and printed in roman rather than italic, for example, dioons. The name of the person who described the species is often put after the binomial, with the date, which is a reference to the Bibliography in *The Cycads.* So, for example, *Bowenia serrulata* (W. Bull) Chamberlain 1912 indicates that Charles J. Chamberlain recognized, at the level of species, a cycad that had originally been described by William Bull as a variety of another species, *B. spectabilis* var. *serrulata* W. Bull 1878.

Some species are divided taxonomically into varieties or subspecies, for example, *Dioon edule* var. *angustifolia* and *D. edule* var. *edule,* or *Encephalartos barteri* subsp. *allochrous* and *E. barteri* subsp. *barteri.* This is done when it is desirable to record distinctions of a permanent character as opposed to temporary distinctions caused by ecological or environmental modification.

Taxonomy

Taxonomic or systematic botany is the science of classifying and naming plants. Some of the fundamentals of naming, or nomenclature, have just been discussed. Taxonomy places emphasis on classification, to express the relationships of plants, and nomenclature provides each group of plants with its correct scientific name.

It has often been stated that taxonomy is an imperfect science. The reason for this statement is that taxonomy is based on plant relationships. To properly understand these relationships it would be necessary to have direct evidence of ancestry for all species, but the evidence consists of scattered fossils, and relationships are generally based on judgment of the similarities and differences of existing organisms. The kinds of evidence used—morphological, cytological, chemical, and so on—and judgment often vary between researchers. Because of this, not all taxonomists agree on every question.

The taxonomic treatment of cycad genera is now based on clear diagnostic features that leave little room for argument. That cannot be said for cycad species. Historically, the separation of cycad species has been based primarily on morphology, the outward differences in leaves, cones, and stems. In some cases there are comparatively minor differences between populations, and taxonomists may not agree on where to draw the boundaries of species. Taxonomists have often themselves been categorized as lumpers, who have a broad species concept, or splitters, who have a narrow species concept. Thus, disagreements between these two camps has resulted in some species being placed in synonymy, only later to be reinstated as distinct species. Changes in cycad taxonomy over time have mostly occurred as the result of more evidence coming to light as a result of further investigation in the field or laboratory, however.

Most cycad species are based on morphological differences and it has generally been assumed that such differences accurately reflect genetic differences, but that is not always true. Differences in growing conditions can, and often do, result in morphological changes. This is easily illustrated by the changes observed when two plants of the same species are grown under different light regimes. The one grown in full sun may have shorter, more compact leaves with crowded leaflets whereas the one grown in shade may have long, broad leaves with widely separated leaflets. Other growing conditions that can affect a plant's morphology include soil, the amount of rainfall, and humidity or the lack of it. In the early days of botanical exploration, many cycad species were based on dried herbarium specimens sent to taxonomists by collectors in the field. Often, a species was based on a single collection consisting of only a single leaf and some cone fragments. Dried specimens often do not reflect the true morphology of a live plant, and descriptions based solely on them are often lacking in accuracy. Descriptions of cycad species should be based also on the study of the plants in habitat, and in cultivation if possible, so that variation may be observed.

Morphological changes may be temporarily affected by changes in a plant's growing conditions. To the extent that morphological changes are genetically based, changes in conditions in the habitat over generations may thus result in genetic changes in plant populations, as different morphologies are selected through the course of time. In this way a group of plants can adapt their morphology to adjust to climatic changes, and they are then better able to survive. This is natural selection, survival of the fittest. When these changes become prominent enough to distinguish a group of plants from other closely related groups, a new species is born. The most effective way to determine whether groups of plants have either temporary or permanent morphological changes is to cultivate them under the same conditions. Using this method, plants with temporary differences will revert to their natural (or original) form, and those with permanent (or genetic) differences will remain the same. It is then up to the taxonomists to decide if the differences are substantial enough to describe a species as new.

When a species is described as new, the description is ideally based on observations of as many plants as possible, in the wild and in cultivation if possible, and on herbarium specimens collected over a period of time. But part of the description includes the designation of a type specimen. The strength of the type concept lies in having a definite entity, a specimen or group of specimens, rather than a written description for a guide. As a rule, written descriptions express only the qualities that the author considers important and may leave out other equally important qualities. In more recent times it has become a general practice to collect and distribute to various institutions several type specimens used in describing a species. In this way, original material is available at several herbaria, ensuring that duplicates are available if a specimen is destroyed, as happened in World War II. The holotype is the one specimen, deposited at one herbarium, to which the new name is permanently attached. Isotypes are duplicate specimens, collected by the same person on the same day at the same locality, given the same collection number, and are as nearly equivalent as possible to the holotype. There are other kinds of type specimens, such as paratypes, specimens other than the holotype or isotypes that are cited in the original description. Some cycad species are based, of necessity, on neotypes, a neotype being a plant specimen chosen to be the type following the loss of all original material. When a genus is described as new, one species is chosen as its basis and is called the type species.

Over the course of time, species have been described and named, each one based on a type. Later, for example, if the boundaries defining a species are drawn so that the species includes more than one type, the correct scientific name for that species is based on the type for the first published name. This is the principle of priority in nomenclature. For example, in the botanical exploration of Australia in the nineteenth century, a number of species of the genus *Cycas* were described, including *C. media* R. Brown in 1810, *C. gracilis* Miquel in 1863, and *C. normanbyana* F. Mueller in 1874. Later, all three (among others) were determined to be in the same species, the correct name of which is thus *C. media.*

CHAPTER THREE

Morphology and Reproduction of Cycads

Stems

Cycad stems are of two general kinds, arborescent or subterranean. Arborescent stems are topped by a crown of pinnately divided leaves, giving the plants the general appearance of palms. Arborescent cycads are easy to distinguish from palms because cycad stems are usually covered with an armor of persistent leaf bases and reduced, scalelike leaves called cataphylls whereas palm stems are generally smooth and circled by old leaf traces. Arborescent cycad stems are generally sturdy, straight, and unbranched, often reaching heights of 5–10 m (16–33 ft) with exceptional species such as *Lepidozamia hopei* sometimes producing stems 15 m (49 ft) high. The stems of some arborescent cycads are decumbent in age (*Encephalartos laurentianus* and *Zamia roezlii,* for example), even pendent in some cliff-dwelling species (*Cycas clivicola* and *E. princeps,* for example). Subterranean cycad stems can also be divided into two kinds, those that retain the scars of old leaf bases, as *Cycas, Encephalartos,* and numerous macrozamias, and those that are tuberous and lack scars of leaf bases, as in *Bowenia, Chigua, Stangeria,* and *Zamia.*

Roots

The primary root in a cycad seedling is a taproot. In subterranean cycads such as *Bowenia,* some species of *Encephalartos, Stangeria,* and some zamias, the taproot has contractile capabilities that tend to pull the stems into the ground. The roots of subterranean cycads tend to be succulent and tuberous, and are well designed as storage vessels for water and nutrients. In arborescent cycads the taproot is generally replaced with a secondary spreading root system whose primary function, besides gathering water and nutrients, is to anchor and support the stem (Plate 4). The roots of the arborescent cycads are more slender, woody, and do not have the storage capabilities of the tuberous roots. The third kind of root found in cycads is known as a coralloid root. These roots branch off the taproot or secondary roots and are distinctive in that they grow laterally or upward, forming a nodular mass at the apex. These coralloid roots occur slightly below or slightly above the soil surface and generally contain cyanobacteria, also known as blue-green algae. Cyanobacteria are able to fix atmospheric nitrogen and make it available as a nutrient to the cycad. The ability to extract this important nutrient from the air explains how many cycad species are able to survive on almost sterile soils.

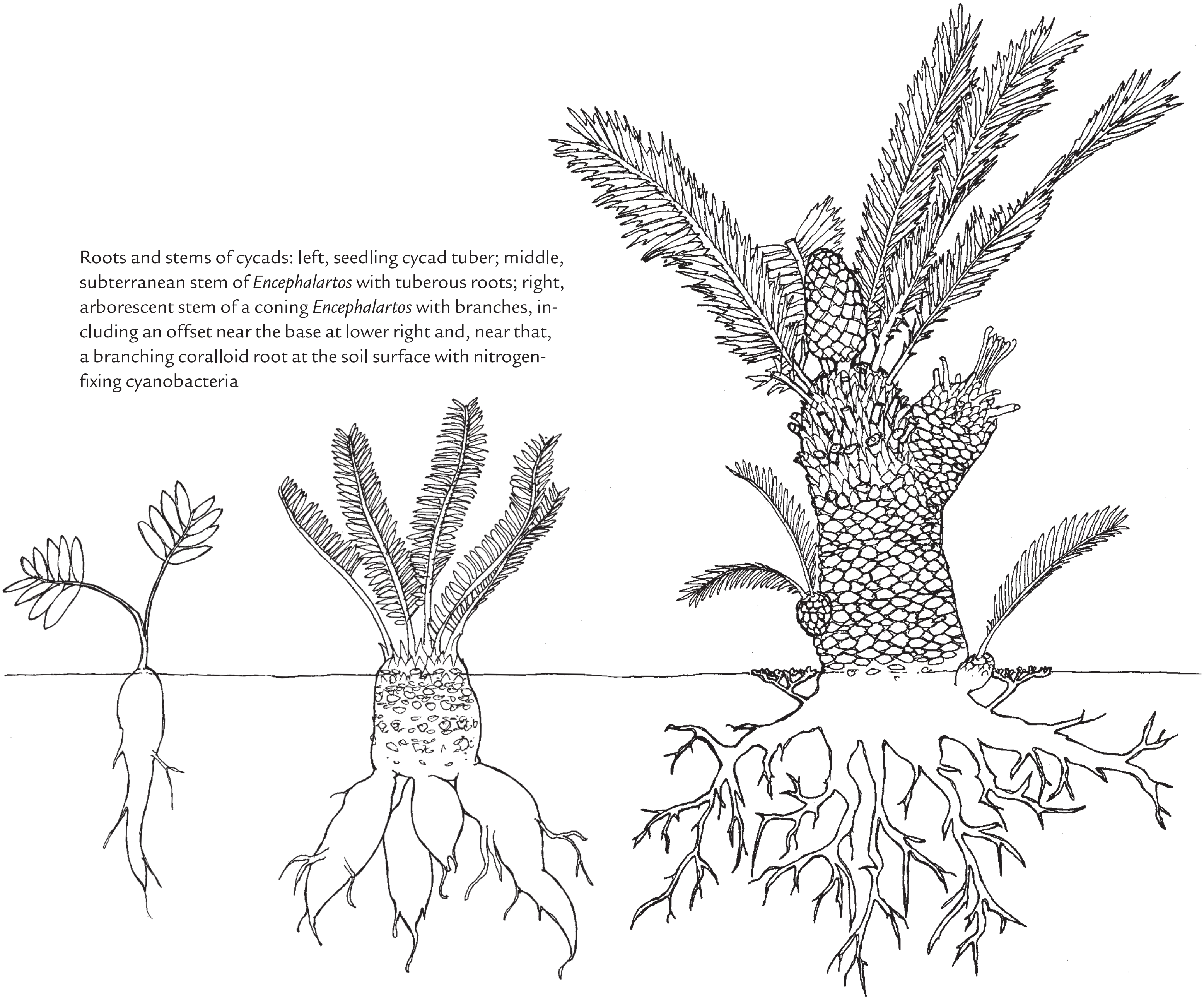
Leaves

Almost all cycads bear pinnate leaves composed of a leafstalk, or petiole, and a stem, or rachis, which bears varying numbers of opposite to alternate pairs of leaflets. Leaf length is extremely variable in cycads, ranging from about 20 cm (8 in) in *Zamia pygmaea* to roughly 7 m (23 ft) in *Encephalartos laurentianus.* The only cycads that deviate from pinnate leaves are the two species of *Bowenia, Cycas debaoensis,* and *C. multipinnata.* These cycads have bipinnate leaves, with secondary branches from the rachis that bear the leaflets.

Most cycads, when producing a new flush of leaves, produce them all simultaneously, but not the species of *Macrozamia* sect. *Macrozamia.* These Australian cycads produce leaves one after another over a long period of time. *Stangeria eriopus* and some species of *Zamia* tend to form new leaves one at a time, also. Many species of *Cycas* tend to be somewhat deciduous, shedding old leaves just before the production of a flush of new leaves. These species occur in areas subject to fires, usually occurring annually, that often defoliate the plants. A common name for *C. armstrongii* in the Northern Territory, Australia, is fire fern. The name was coined because shortly after fire passes through a colony, all the cycads produce new leaves. Even without the annual fires, the leaves of these *Cycas* species generally die before new leaves are produced.

Emergent cycad leaves are covered to a greater or lesser extent with epidermal hairs called trichomes. When hairs are present in great number the leaves are referred to as tomentose. In some species of cycads the leaves are so densely covered with these hairs that they appear woolly. In almost all cycads this covering soon weathers away from the leaf surface, but in some such as *Encephalartos hirsutus* the tomentum persists for many months. Generally, mature cycad leaves are glossy and smooth. The leaves of cycads in rain forests are often covered with algae, mosses, or lichens. At times this covering can be so thick as to completely obscure the surface of the leaflets.

Mature cycads produce three kinds of leaflike organs: the leaves themselves, the cataphylls (reduced scalelike leaves), and the reproductive cones (a modified crown of leaves). In *Cycas* the female cones are composed of either tightly overlapping or open and pendent sporophylls, as opposed to the true cones of all other genera of cycads. In mature cycads these foliar organs are generally produced in a regular sequence during the growing period. The cataphylls are produced first, followed closely by the production of a new crown of leaves or a reproductive



Roots and stems of cycads: left, seedling cycad tuber; middle, subterranean stem of *Encephalartos* with tuberous roots; right, arborescent stem of a coning *Encephalartos* with branches, including an offset near the base at lower right and, near that, a branching coralloid root at the soil surface with nitrogen-fixing cyanobacteria cone, then more cataphylls. Close observation discloses that the leaves, cataphylls, and cones are all arranged in a spiral pattern. Cataphylls take several forms and it may be noted that those produced before the leaves are much shorter than those produced before the cones. Generally, cataphylls are somewhat succulent when fresh, and papery and flexible when dry. This is not always the case, however, as some species of *Cycas* have cataphylls that are stiff and spinelike.

Leaflets

Cycad leaflets display a wide variation in size, shape, texture, color, veins, attachment, and margin. Leaflets can be very large, as in *Zamia wallisii* with leaflets 50 cm (20 in) long, 30 cm (12 in) wide, or very small, as in *Z. pygmaea* with leaflets 3 cm (1.2 in) long, 1.5 cm (0.6 in) wide. Leaflet shape varies from long and narrow, short and broad, lanceolate to obovate, straight to falcate, and sometimes, as in *Cycas micholitzii* and some species of *Macrozamia* sect. *Parazamia,* one to three times dichotomously divided.

Leaflet texture can be papery, leathery, or rigid. The leaflet surface can range from smooth and glossy, as in *Zamia splendens,* rough and uneven, as in *Z. furfuracea,* to prominently corrugated, as in *Z. skinneri.* Generally, corrugated leaflets are the result of the major parallel veins being sunken into the leaflet surface.

Leaflet color varies from yellowish green, glaucous green, through various shades of light to dark green, purplish green, bronze-green, finally to silver or blue, these last two colors produced by a waxy coating on the leaflet. In *Zamia variegata* the dark green leaflets are spotted and lined with yellow.

Leaflet veins in most cycads are parallel to the long axis of the leaflet, though lateral veins are found in *Stangeria.* Leaflets of *Chigua, Cycas,* and *Stangeria* display a midrib. In *Cycas* the midrib is composed of a single vein whereas in *Chigua* and *Stangeria* the midrib is formed by the unification of numerous parallel veins.

Leaflet attachment to the rachis may be divided into two kinds, articulated (jointed), as in *Ceratozamia, Chigua, Encephalartos, Microcycas,* and *Zamia,* or permanently attached, as in *Bowenia, Cycas, Dioon, Lepidozamia, Macrozamia,* and *Stangeria.* Articulated leaflets break away easily and cleanly from the rachis as the leaf begins to die. The rachis, however, remains attached to the cycad stem somewhat longer before it is shed. Permanently attached leaflets are decurrent—the lower leaflet margin continues down the rachis—and leaflets stay attached to the dead leaves.

A leaflet stalk is sometimes present and is known as a petiolule. It can be simple, as in *Zamia montana* and *Z. wallisii,* or have a glandular collar where the leaflet joins the stalk, as in *Z. manicata* and *Z. macrochiera.* In *Macrozamia* each leaflet has a swollen, green or colored callus at its attachment.

Leaflet margins are often entire but generally exhibit serrations, teeth, spines, or spine-tipped lobes. The margins may be flat, undulate, revolute, or swollen.

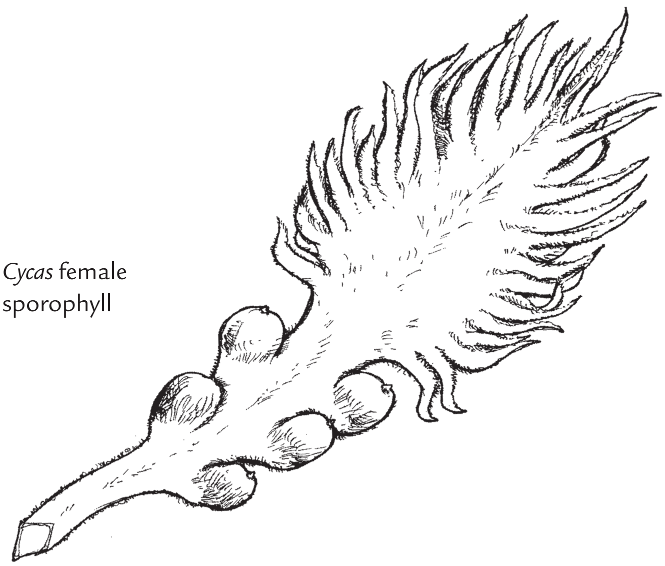
The insertion of the leaflets into the rachis can also vary in several ways. Generally, leaflets are inserted flat and horizontally, but they can be keeled (held obliquely erect to form a V as in *Dioon califanoi*) or deflexed (drooping downward to form an inverted V as in *Microcycas calocoma*). Some leaflets are twisted at the base, turning them at right angles to the rachis and aligning them like the slats of a partially open Venetian blind. The leaflets can be twisted so as to overlap them in an upward or downward direction. Leaflets are most commonly inserted at right angles to the rachis but are often inserted so as to be angled forward or backward on the rachis.

The length of the leaflets usually varies from the base to the apex of the leaf, the longest leaflets generally occurring at midleaf. In *Microcycas calocoma* the leaflets remain almost the same length from the leaf base to the apex, giving the leaf apex an unusual cut-off appearance. Often, basal leaflets are gradually or rapidly reduced to spines.

Cones

Cones are the reproductive organs of cycads and are composed of highly modified leaves known as sporophylls that are spirally aggregated into a conelike structure. Each female sporophyll carries ovules, usually two, and each male sporophyll carries numerous sporangia (pollen capsules), generally on its lower surface. The only cycads without sporophylls aggregated into true cones are females of the genus *Cycas,* which have either tightly overlapping or open and pendent sporophylls. *Cycas* is also the only genus that normally has more than two seeds attached to each sporophyll, in some species as many as 8–10. Cycad cones somewhat resemble cones of other conifers such as pines and spruces; the cycad cones are generally much larger, however. Some female cycad cones are more than 75 cm (30 in) long and weigh as much as 40 kg (88 pounds). Male cones are usually smaller than the females, with more numerous, generally smaller sporophylls, and are usually cylindrical to long conical in shape.

The morphology of cycad sporophylls varies considerably between genera and has proven to be a good character in distinguishing them. The exterior surface of the sporophylls, which I refer to as the sporophyll face, can in many cases immediately identify the genus. Although the sporophylls of *Bowenia, Chigua, Microcycas,* and *Zamia* are somewhat similar in appearance, they can be easily distinguished when leaves are included in the comparison. Female cones of *Dioon* and *Stangeria* both have flattened scalelike sporophylls but differ in that *Dioon* has a pointed apex and is heavily tomentose to woolly, whereas *Stangeria* has a rounded apex and is short tomentose. *Ceratozamia* has two prominent horns on the sporophyll face, and *Macrozamia* generally has a single sharp, upright spine. The sporophylls of *Lepidozamia* somewhat resemble those of *Macrozamia* in that they have a single arching appendage on the sporophyll face, but this appendage is soft and not tipped with a sharp spine. The sporophylls of *Encephalartos* generally have the face divided into three to seven flat planes called facets. The central or terminal facet is surrounded both above and below by one to three smaller facets. The surface of these facets may be smooth, wrinkled, or warty and may be covered with sparse to dense tomentum, or completely glabrous. Female sporophylls of *Cycas* are unique in that they do not form a conelike structure but either tightly overlap each other or hang. Their sporophylls may be more than 30 cm (12 in) long and are composed of a stem or stalk that carries 1–10 seeds along its sides, and a terminal lamina. The lamina is a flat, leaflike structure that generally has numerous spine-tipped divisions and is usually densely tomentose. The resemblance of the female *Cycas* sporophyll to a leaf is not difficult to see. Males of *Cycas* do form a conelike structure, and their sporophyll face usually has a soft, erect, spinelike appendage.



Cycas female sporophyll

Sex Expression

All cycads are dioecious—any individual plant is either female or male. No cycad has been known to produce both female and male cones on the same plant at the same time. There have, however, been several occurrences in which cycads have changed sex. In all such cases the plant had usually suffered some sort of trauma, such as an almost unsuccessful transplant in which the cycad had been close to death, or was the result of extreme damage caused by cold, heat, or drying. There was one case in which a female *Encephalartos latifrons* that had been growing in a garden for 16 years suddenly produced male cones. The only cause that could be identified was an extended period of drought. Sex reversal is very rare and only about two dozen documented cases are known, both from male to female, and female to male. In my collection I have had three species of cycads change from male to female: *Ceratozamia matudae, E. senticosus,* and *Zamia fairchildiana.*

More recent studies indicate that a balance of hormones in the plant's system controls sex expression in dioecious plants. Experiments are in progress, testing several auxins and growth regulators to try and induce sex changes in cycads. The general prognosis is that it will be possible. If this is accomplished it could be an important tool in the conservation of endangered cycads. At present, there is no way to predict the sex of an immature cycad. The only indication of its sex occurs at the time the first cone is produced. Plants propagated vegetatively from an individual cycad will be the same sex as the parent. That should also hold true of any plants produced through tissue culture. There is, however, always the possibility of mutation taking place in tissue culture, which could conceivably produce a sex change.

Cycads generally have a season in which the growth cycle, consisting of new leaf and cone production, takes place. This growth cycle usually starts in the spring and is no doubt triggered by longer periods of daylight, warmer temperatures, and the advent of the rainy season. Virtually all cycads grow in areas of summer rainfall, and the rains generally mark the periods of new growth. In an immature cycad, the production of leaves and enlargement of the stem mark each growth cycle. Once an individual reaches maturity, which is marked by the production of the first cone, the regular pattern of leaf production may be somewhat altered. In some cycads, leaf and cone production may alternate with leaves produced one year, cone(s) the next. There are cycads that produce cones, then leaves in one growth cycle, and others that produce a crown of leaves, followed closely by a cone. Many variables can affect the sequence of leaf and cone production, for example, the condition of the plant, or unusual weather patterns with unseasonable hot or cold spells. Particular genera or species also seem to have coning patterns that may be frequent or infrequent. Some species may go several years between periods of prolific coning.

Male Cones

Differences between female and male cycad cones are mainly size, and number and size of the sporophylls. Male cones are generally much smaller in diameter and exhibit a sporophyll face about a quarter the size of those produced by the female. Although there are exceptions such as *Encephalartos aemulans, E. heenanii,* and *E. manikensis,* the number of sporophylls in the male cone is usually much greater than in the female. The individual male sporophyll is generally somewhat wedge shaped, with its lower surface covered with sporangia (pollen capsules). In *Zamia* there are some exceptions in which sporangia also occur on the upper surface or edges of the sporophylls.

As the male cycad cone matures, there is rapid elongation of the cone axis, causing a marked increase in length. The sporophylls separate, exposing the sporangia. Shortly after this elongation takes place, and possibly as a result of drying, the sporangia crack open, and the microspores (pollen grains) are shed onto the smooth upper surface of the sporophylls directly below. The ripening and rupturing of these sporangia follow a pattern starting at the base of the cone and progressing upward. The sporangia on each sporophyll ripen from the back (those closest to the cone axis) to the front.

Historically, cycads were thought to be wind pollinated, but more recent studies of several species have revealed all to be insect pollinated. Other experiments, which excluded either insects or wind, disclosed pollination by insects but not by wind. During cone elongation there is usually a dramatic increase in the cone's temperature, which is usually also associated with the production of odor. The various odors are easily detected and can be described as musty, fruity, or sweet. It has been suggested that the elevated temperatures assist in the volatilizing of these odors. Peak cone temperatures are produced in the evening and early morning. It seems obvious that all these traits point to insect attraction and pollination. These findings also explain how a single female plant can have a cone with fertile seeds while no male plants can be found anywhere in the area. Virtually all the insects found pollinating cycads are beetles, the majority of them weevils (Plate 5). Research into insect pollination has disclosed that some of the insect pollinators may be host specific.

The process of pollen shedding may be completed in as short a time as 5 days or it may take as long as 5–8 weeks. Generally, the warmer the temperature, the more rapidly pollen shedding is completed. In many species of cycads, pollen shedding is prolonged by the production of numerous male cones that mature in sequence. In this way, pollen may be produced over a period of several weeks.

Female Cones

Female cones of cycads are generally larger than those of the males, especially in diameter. Also, the female cones have fewer, generally larger sporophylls. Each sporophyll is attached to the cone axis by a stalk, which in turn is connected to the bulla or outside face of the sporophyll, referred to in this book as the sporophyll face. On the inside of the sporophyll face, the side facing the cone axis, two ovules are attached, one on each side of the sporophyll stalk (Plate 6). The apex of the ovule (the end closest to the cone axis) contains the micropyle or pore through which the ovule is pollinated. When a female cone becomes receptive, small to large cracks appear between the sporophylls, generally at the cone apex but sometimes at the base or sides of the cone as well. In some cycads, spaces appear between all the sporophylls. In *Cycas,* the female's receptive state is not usually so clearly defined because the sporophylls are not compressed into true cones. In *Cycas* there are two types of cone: open, in which the sporophylls are long and lax, and closed, in which they form a moundlike cone. A close watch must be kept on the micropyle of the ovule in order to observe the drop of liquid that appears there, signaling the receptive condition. A small number of cells break down at the tip of the ovule, forming a drop of clear, sticky substance that exudes from the micropyle. The breakdown of these cells results in the formation of a minute hollow or pollen chamber beneath the micropyle. Detecting receptive *Dioon* cones can also be a problem, especially in the species of the western coast of Mexico, which have female cones completely covered with a thick tomentum, making the receptive stage all but impossible to observe. Dioons of the eastern coast generally have the two bottom rows of sporophylls free of tomentum, and it is there that the cones open, allowing insects to enter and pollination to take place.

During the receptive stage, the female cone also undergoes a rise in temperature and concurrent emission of odor, no doubt attracting insect pollinators. These same insects may be attracted to the nectarlike droplet at the micropyle, in which the transported pollen may be trapped. As the receptive stage passes, the sticky droplet dries and is drawn, along with the trapped pollen, into the pollen chamber, thus sealing the micropyle. Within the pollen chamber a pollen grain ruptures and forms a pollen tube, which penetrates the tissue surrounding the pollen chamber. The pollen tube acts like a parasite within the ovule, feeding on the ovule's tissues for several months as the tube grows. As the tissues of the ovule recede, the pollen chamber gradually enlarges until the pollen tube(s) reach the female gametophyte, which is approaching sexual maturity.

During pollen tube growth the sperm have matured and developed the cilia that will make their movement possible. For several hours they swim about in the pollen tube, at first slowly, then more rapidly. The pollen tube ruptures and the sperm break free, to be drawn into the neck of the egg sac. The entry of the sperm into the egg sac usually removes its sheath and band of cilia, leaving the male gamete or nucleus free to seek the female gamete or nucleus of the egg. Shortly after contact is made, the male nucleus embeds itself into the female nucleus and fertilization has taken place.

The time from pollination to fertilization may be as long as 7 months. In some cycads such as *Lepidozamia* it appears that fertilization does not take place until sometime after the seed has been shed from the cone. The next step is the division of the nucleus formed by the fusion of the nuclei of the egg and sperm. The division of this original nucleus continues rapidly, forming 2, 4, 8, 16, 32, 64, 128, 256 nuclei, sometimes 512 or 1024, before cell walls start to form. This interval is called the free nuclear stage in the development of the embryo. The actual mass of the original nucleus does not increase, but the size of each nucleus is halved with each division, the nuclei becoming smaller as they become more numerous. When the first permanent cell walls are produced, the cells begin to separate into three regions. At one end the cells absorb stored nutritive materials and cease to function when all of the nutritive materials have been absorbed and passed on. In the middle, cell elongation takes place rapidly, forming the suspensor, a long, coiled, threadlike structure that is attached to the true embryo at the other end, which in time will form the seedling cycad. Development continues rapidly as the embryo elongates, and the two cotyledons or seed leaves, much reduced in cycads, become differentiated. Following the development of the cotyledons, the stem tip gives rise to the first embryonic leaves. By the time the seedling has completed its intraseminal development, the term describing the seedling prior to its breaking through the seed coat or sclerotesta, it generally has one well-developed foliage leaf, and another one or two distinguishable microscopically. After this stage is reached the seed is ready to germinate. Germination of the seed is usually triggered by a combination of heat and moisture.

Seeds

Newly ripened cycad seeds are usually composed of four parts. The integument has three layers: an outer fleshy layer called the sarcotesta, a central stony layer known as the sclerotesta (or shell), and an inner membrane called the endotesta. These three layers surround and protect the central kernel, which contains the female gametophyte or megagametophyte, eventually the embryo. Those species belonging to the *Cycas rumphii* complex have an additional layer of spongy tissue located inside the sclerotesta. This spongy tissue allows the seed to float in water and is thought by some to aid in dispersal from island to island by ocean currents. Species of the *C. rumphii* complex are basically seashore plants.

Cycad seeds are produced in a wide range of size, shape, and surface texture. The largest seeds are probably those of *Macrozamia macdonnellii* or *Cycas micronesica,* and the smallest, *Zamia pygmaea.* The shape of most cycad seeds is generally ovoid, egg shaped, but they may also be globular or cylindrical. Seeds of the *C. rumphii* complex have a distinctive apical crest that distinguishes them from others in the genus. Some seeds have a definite point at the chalazal (attachment) end, and others are rounded. The chalaza, the scar where the seed was attached to the sporophyll, may be large or small, smooth or pitted, and flattened or extended. The sclerotesta surface is extremely variable and can be smooth, rough, pitted, fibrous, or ridged.

Cycad seeds and seedlings are divided into two groups, platyspermic and radiospermic. Platyspermic seeds are restricted to the genus *Cycas* and are somewhat flattened, splitting longitudinally at the broad end, dividing the sclerotesta into two equal parts. As the crack widens it exposes the female gametophyte, and shortly thereafter the radicle emerges. All other cycad genera have radiospermic seeds, which have a round pore that is sectioned like a cut pie at the end with the micropyle. As the seed germinates, the radicle, which lies directly behind the pore, exerts pressure and breaks through. The radicle completely fills the pore, protecting the embryo from the entry of fungi or bacteria.

Seedlings

The radicle grows downward until it comes into contact with the soil, at which time root tissue begins to form. The root enters the ground and begins its growth. After the development of the taproot, which is also a food and water storage vessel, the two cotyledons or seed leaves, which form the radicle, separate, and the first leaf emerges. At this stage of development, cataphylls (reduced scale-like leaves) and leaves are produced successively at the bud. In a normal growing season, one or more leaves may be produced. At some point the taproot or tuber, or other roots in some cycads, will become large enough to sustain the production of multiple leaves. The number of leaves produced in a single growth cycle will increase each year until the normal complement of leaves for a mature plant is reached. During this period of growth, the stem will have been expanding laterally as well as vertically. The stage at which the cycad first produces a full complement of leaves is when the diameter of the stem reaches its normal mature girth. From that time, each growth cycle, producing cones or foliage, will add more to the height of the stem than to its diameter. It is at this stage that the stem will clearly begin to exhibit the alternating rows of foliar rings and cataphylls (Plate 7).

Cycad Variants and Hybrids

Variation within a plant or animal species is the result of individual differences in response to environmental conditions, genetic differences or mutation, and hybridization.

Environmental Variation

Plants of the same species often differ from each other as a result of being subjected to differences in environmental conditions. Plants grown in poor soils do not grow as large as plants of the same species that grow in fertile soils, for example. *Dioon spinulosum,* growing out of a limestone crack, will be dwarfed until such time as its roots find their way into a pocket of soil or leaf mold. The change in size induced by the different growing conditions is not transmitted to the plant's offspring, however. Although the flexibility of response to environmental differences may be genetically based and thus inheritable, the expression of a particular response is part of that flexibility and is not itself inherited. Differences in environmental conditions operating through long periods of time may select for particular responses, of course, but such evolutionary changes should not be confused with temporary modification.

Mutation

Individuals of a population usually differ somewhat in their genetic makeup to different degrees. Often, the changes in DNA that lead to many of these differences are small, but sometimes the changes are dramatic. When these changes are the result of sudden, unpredictable inheritable changes that cannot be explained by environmental modification or hybridization, they are called mutations. Examples of such mutations in cycads are plants with variegated leaves, plants with monstrous leaves, or plants with cristate stems.

Variegated Plants. There are essentially two kinds of variegation found in cycad leaves. The most common form is the occasional striping of leaflets with white or yellow (Plate 8). Less common are aureate plants, which exhibit foliage of an overall golden color. In my experience, almost all forms of variegation in cycads require solar bleaching to develop the variegated areas in the leaves. When grown in deep shade, variegated cycads seldom develop the lighter areas and remain green.

For many years variegation was thought to be the result of viral infection. Because of that, many variegated plants were destroyed to keep the infection from spreading. We now know that most variegation is caused by mutation, and because of that the variegation is inheritable.

There are only three known naturally occurring variegated cycads. One is *Zamia variegata* from Guatemala and southern Mexico, and possibly Honduras and Belize. When grown from seed, *Z. variegata* exhibits a great deal of variation in the amount of variegation of its leaflets. Some offspring may be almost completely green while others are densely spotted and striped with yellow. Another naturally occurring variegated cycad is an aureate form of *Cycas revoluta* that grows on the small island of Kume in the Ryukyu Islands, Japan (Plate 9). When this cycad produces new foliage in the spring, it emerges golden yellow. The yellow color darkens during summer, and in the fall the foliage slowly turns green.

Japanese cycad collectors cultivate another variegated form of *Cycas revoluta* to which they refer as "variety *aurea.*" In this form all leaflet tips are golden yellow. In mutations from Amami, Ryukyu Islands, the yellow leaflet tips are immediately apparent on emergent leaves but they die and turn brown as the leaves age. Another mutation, also from Japan, is known in which the leaves are green when emerging and subsequently develop permanently yellow tips.

Another yellow form, of *Cycas seemannii,* is commonly cultivated as an ornamental in the Fiji Islands. This cycad is commonly referred to as the golden *Cycas* and is believed to have come originally from Vanuatu, west of Fiji. It is commonly found as a garden plant in Suva, Fiji, where it is easily propagated from stem offsets. Unlike the aureate form of *C. revoluta* in the Ryukyu Islands, the leaves of this *Cycas* are green when emerging and gradually turn golden yellow with exposure to the sun.

I have a specimen of *Dioon edule* that exhibits the yellow leaflet tip mutation in emergent leaves. Like the similar mutation of *Cycas revoluta* from Amami, the leaflet tips turn brown as the leaf ages. I also have a variegated specimen of *Encephalartos natalensis* (Plate 10) that was sent to me many years ago by Cynthia Giddy. She discovered this plant as one of several offsets growing at the base of a large specimen in a hotel garden. There was no variegation apparent on the mother plant or any of the other offsets. Somatic mutations such as this are quite rare.

During many years of raising cycads from seed I have from time to time germinated variegated seedlings, but only a handful of variegated seedlings have been produced in my greenhouse in more than three decades. Because they have less photosynthetic tissue, variegated cycads are generally slower growing and less robust than their normal green siblings, and this no doubt limits their survival in the wild.

From time to time, seedlings are seen with white emergent leaves that are completely lacking in chlorophyll. These seedlings are unable to photosynthesize and die soon after the endosperm has been absorbed from the seed.

Monstrous Plants. Mutations may result in the production of monstrous or abnormal plants. This type of mutation is not at all uncommon when large numbers of cycads are grown from seed. Monstrous cycads have thickened leaflets with irregular margins that are sometimes lacerate, or thickened or twisted stems. Many of these mutations cannot be described as anything but ugly, but others range from interesting to beautiful. Beauty is in the eye of the beholder.

Monstrous plants may be produced by any of the cycad genera but seem to occur most frequently in the faster growing ones. Such mutations occur commonly in *Zamia* and somewhat less frequently in *Ceratozamia, Cycas,* and *Encephalartos.* The occurrence of monstrous leaves in *Z. furfuracea* is reasonably common, and these unusual specimens have become popular with collectors.

I have three mutant specimens of *Encephalartos horridus* that produce leaves in which each leaf is essentially a single irregular leaflet (Plate 11). My largest specimen is more than 14 years old and has a stem greater than 7.5 cm (3 in) in diameter and numerous leaves about 15 cm (6 in) long.

Cristate Plants. Some mutations produce cristate or crested plants and leaves. Cristate plants have a fan-shaped stem apex that produces numerous small leaves along its terminal margin. This mutation is found in *Cycas revoluta,* and in Japan, cristate branches are often detached, rerooted, and grown as bonsai. Cycads with cristate leaves are rarely encountered though I have seen two specimens of *C. revoluta* exhibiting this mutation as well as *Zamia furfuracea* (Plate 12). This condition is sometimes referred to as fishtail leaves because the leaf is shaped like the tail of a fish. Apparently, several wild specimens of *Encephalartos transvenosus* with cristate leaves have been discovered (Claassen 1993), and the phenomenon is known to occur in *Ceratozamia hildae* (Plate 13).

Hybridization

Hybridization may be a source of variation, in the wild or in cultivation. Crossbreeding two species often results in first-generation hybrid offspring, the F_1 generation, with some characteristics intermediate between the two parents. Natural hybrids in cycads are usually the result of overlap in the ranges of two compatible species, *Encephalartos altensteinii* and *E. villosus,* for example. But natural hybrids are generally not common even where colonies of two species occur. Hybridization between two genetically compatible species is thought to be limited by biological rather than geographical barriers. Such a barrier might be a difference in coning season, for example, with one species coning earlier and its pollen thus not available when females of the other species are receptive. Hybrids may be produced by unusually early (or late) coning of one of the species.

At least some species of cycads may be pollinated by host-specific pollinators. If two overlapping, genetically compatible species were to have different pollinators, a natural barrier to their hybridization would exist. Occasional hybrids might occur through wind pollination if opposite sexes of the two species were close enough. In some mixed populations that I have examined, there did not appear to be any natural barrier to cross-pollination and hybrids were quite common, between *Encephalartos horridus* and *E. longifolius,* for example (Plate 14). Not only were intermediate F_1 hybrids common, there were also F_2 offspring, whose characteristics were closer to one parent or the other, no doubt mostly because of backcrossing of an F_1 hybrid with one of the parents. Such an example occurs in a mixed population of *Zamia amplifolia* and *Z. chigua* (Plates 15–18).

Artificial hybrids are produced by hand pollination, often between species that do not come into contact with one another in nature. Hybrids produced accidentally in cultivation would also be classified as artificial. The only barrier to artificial hybridization would be genetic incompatibility, between cycad species with different numbers of chromosomes, for example.

There are two schools of thought regarding cycad hybrids. Purists believe that any dilution of the gene pool, especially of rare species, is uncalled for and dangerous to the survival of that species. Such a problem could occur if the hybrid was misidentified as the species and used for propagation. This is a remote danger in most hybrids, which are produced only as an F_1 generation that does not closely resemble either parent. The same cannot be said for hybrids of an F_2 generation, as some individuals would more closely resemble one parent or the other.

On the other hand, hybrid cycads may be beautiful plants that please the cycad grower. In addition to cycads with new characteristics that can be produced through artificial hybridization, the F_1 generation usually exhibits hybrid vigor. Almost all such hybrids are stronger and faster growing than their parents. Both attributes would be welcome in any cultivated plant, but especially in cycads. There are several hybrid cycads I have seen that would be worthy additions to a collection, including *Encephalartos natalensis* × *E. woodii, E. latifrons* × *E. altensteinii, E. eugene-maraisii* × *E. concinnus,* all garden hybrids, and *E. longifolius* × *E. horridus,* a naturally occurring hybrid. All these examples are *Encephalartos,* and that is because hybrids are more easily identified in *Encephalartos* than in the other genera of cycads. Some potentially interesting crosses have been made between species within the genera *Ceratozamia* and *Zamia.* No doubt, additional noteworthy hybrids will be added to the list as time goes on.

CHAPTER FOUR

Cultivation of Cycads

Successful garden culture of cycads requires five basic elements: warmth, well-drained soil, sufficient light, sufficient water of good quality, and fertilization. When these five elements are properly supplied, many years of trouble-free cycad growing may be expected.

Temperature

In nature, almost all cycads are native to subtropical or tropical habitats. In cultivation, many cycads will grow exceedingly well in temperate to warm temperate climates, but the majority seem to prefer subtropical conditions. A few cycads require tropical climates with heat and high humidity, and those species do not respond well to cooler climates. For these reasons, the beginning collector must research the cycads and choose only those that will do well under the conditions that can be made available in cultivation. Failure to do so can result in either the loss of plants, or plants that look sickly and detract from the beauty of the garden.

The most critical temperatures in the cultivation of cycad seedlings tend to occur during the coldest times of the year (Plate 19). Many cycad species can withstand short periods below freezing. Extended exposures to freezing or subfreezing temperatures usually produce some damage to the leaves, stem, or roots. In some cases, death of the cycad can be caused by one such exposure. Or damage may be apparent the first day and may subsequently cause the death of the entire plant. In most cases, leaf burn or defoliation may be noted in 2–5 days. The degree of damage depends most importantly on the overall condition of the individual plant. A plant in good health can withstand exposure to cold temperatures far better than a sick one. Also, the genetic makeup of the plant may cause it to be cold tolerant even if the plant in its native habitat is not exposed to cold.

Generally, plants from more temperate habitats seem to have considerable immunity to occasional cold snaps. There are also cycads, *Encephalartos cycadifolius* and *E. ghellinckii,* for example, whose habitats occur at high elevations, where they are exposed to cold and snow. Even when substantially damaged by cold, the recuperative powers of cycads are considerable. I have seen cycads that have been completely defoliated by freezing and damaged to such an extent that the apex has rotted out of the stem. Within a few years, a new crown and leaves have been regenerated. But in almost all cases, cold weather, especially subfreezing weather, must be considered detrimental to a cycad's survival and good health.

Extreme heat can also damage cycads, and periods of high temperatures coupled with low humidity can cause considerable damage to leaves. The damage is usually in the form of scorched or burned leaf surfaces. This type of damage can make a cycad unsightly until new leaves are produced, but usually heat damage is neither permanent nor extensive. It is only small seedlings that may be badly damaged or killed by hot sun. An air temperature of 38°C (100°F) can result in a temperature as high as 66°C (150°F) at ground level. A temperature that high would be enough to cook a small seedling in a short time.

Optimal growing conditions as far as temperature range is concerned would be no extreme highs or lows. Hawaii is a good example of a place with optimal conditions for growing cycads. Trade winds keep highs near 27°C (80°F), and the ocean's influence keeps lows at about 16°C (60°F). Since this temperature range is more or less stable all year, plant growth is rapid and continual. Cycads growing under these optimal conditions may produce several growth cycles, either leaves or cones, in a 12-month period. The only disadvantage in growing cycads under such favorable climatic conditions has been the reluctance of some species to produce cones. The species involved are generally those from habitats experiencing cold winter conditions. These species may need a greater fluctuation between maximum and minimum temperatures to induce coning.

Soil

An almost universal requirement for the proper cultivation of cycads is a well-drained soil. By far the best soils for cycads are sandy gravels and light loams. These two soil types provide the required drainage and aeration necessary for good growth. Cycads will generally not grow well in clay soils unless those soils are heavily amended with sand and organic matter to increase aeration and drainage. A planting hole should never be dug in clay soil and then filled with planting soil as this produces a basin that can collect water and keep the root ball too wet. That results in root rot, which often destroys the entire plant. Constantly wet, soggy soil conditions should be avoided. Mounding good soil on top of clay to produce a planting area is one way to overcome this problem.

Soil pH also plays a role in the optimal growth of most cycads. A neutral soil (pH equal to 7), is generally best for most species of cycads and allows the proper absorption of nutrients. A slightly acid soil (pH less than 7) is better for most cycads than a basic one (pH greater than 7). Mulching is beneficial to minimize water loss and to keep the soil surface moist. *Ceratozamia* and *Stangeria* seem to prefer a constantly damp root run and will benefit from the application of mulch.

The soil should also contain enough organic material to hold nutrients. There is no soil mix that will work well in all climates and under all conditions, however. Areas with high humidity and rainfall should have a light, well-drained soil for cycads. Conversely, areas with more desertlike conditions will require a soil that retains more moisture. Those able to water their plants individually may be able to use several mixes. Generally, any mix that works well for plants adapted to dry conditions, such as cacti and other succulents, will be acceptable for cycads. One must experiment with various mixes until the right combination for a particular climate and watering schedule is discovered. Watering schedules should be adjusted to compensate for soils that are particularly heavy, or porous. Keep the soil damp but not wet. If cycads are grown in pots, the type of pot plays a role in this. Plastic pots hold moisture longer than a similarly sized clay pot and should not be watered as often.

Light

Light requirements of cycads vary. Most species of *Bowenia, Ceratozamia, Chigua, Lepidozamia, Macrozamia, Stangeria,* and *Zamia* require low-light conditions or full shade. Most species of *Cycas, Dioon,* and *Encephalartos,* and *Microcycas calocoma,* do better in full sun. There are exceptions, of course, such as *Z. furfuracea,* preferring sun, and *E. villosus,* preferring shade. The cultivation requirements for particular species are noted in the remarks following the descriptions in Chapter 8. Some shade-loving species will tolerate full morning sun but not afternoon sun. Morning temperatures are cooler and humidity is generally higher. Later in the day, higher temperatures coupled with lowered humidity may cause leaf burn in shade-loving species. Very few cycads, even those from rain forest habitats, will grow well in dense shade.

Cycad seedlings should be protected from exposure to full sun for at least 5 years. Exceptions would be most species of *Ceratozamia,* those with broad leaflets, and the shade-loving species of *Zamia,* which should always be shaded. Even seedlings of cycads from extreme desert areas, such as *Encephalartos horridus,* need protection during their juvenile stage. Cycads of hot, dry areas survive as seedlings by growing under the protection of other plants. In southern California, I have found shade cloth producing 40–50% shade to be the best all-around choice. The light delivered to the seedlings will be sufficient for the desert species while being dark enough for the forest species. When the seedling has reached the age of 5 years, it has usually produced a stem about the size of an orange. At this size it can be planted in full sun. Some leaf burn may occur, but when new leaves are produced they will adjust to the changed light conditions and not burn.

For those who keep cycads as pot plants the following suggestion is made. Always indicate a standard direction by some means such as label placement or by marking the edge of the pot. Any direction will do. I use west and place my labels on the west side of the pot. Then, when a pot is moved it can be oriented in the same direction, which helps avoid sunburn of leaves that are used to receiving different amounts of light because of their different orientations to the sun's rays.

Water

Water is crucial not only to proper growth but also to the survival of cycads. Sufficient water must be delivered periodically to completely soak the root system, and to maintain soil moisture between waterings. The stem and roots of cycads are organs of water and nutrient storage. Because of their ability to store water and nutrients for future use, cycads have been able to survive in dry habitats. In cultivation, most cycads grow more rapidly than they will in their natural habitat, largely because of the more frequent availability of water. In their natural habitat, most cycads receive summer rainfall followed by dry winters. Those who live in a Mediterranean climate with winter rainfall must limit watering of cultivated cycads to the summertime. Cycads seem to adjust to winter rainfall as long as they are in a well-drained soil and can be watered during the dry summer months.

Water quality is important to the proper growth of cycads. Natural rains provide the best water. Rainwater is generally pure, without dissolved salts, and slightly acid—all beneficial to cycads. Water pumped from wells or obtained from rivers is often hard, that is, rich in dissolved minerals. These minerals, depending on what they are, can be either beneficial or detrimental to a cycad's growth. A high dissolved salt content often interferes with the uptake of necessary nutrients. Even when the soil receives large applications of fertilizer, the nutrients become locked away and are unavailable to plants irrigated with water that is too rich in salts. Some hardy cycads, especially those from desertlike areas, may grow reasonably well in spite of water containing a high percentage of dissolved salts. Other cycads, particularly those from rain forest areas that receive large amounts of rainfall, cannot tolerate water contaminated with dissolved salts. Those plants generally require pure water that is slightly acid for best growth and health.

Hard water usually has a pH well above 7. It is beneficial to try and lower the pH to a slightly acid condition. Adding chemicals to the water or the soil can accomplish this. Even if it is necessary to use water with a high pH, most cycads are very adaptable and may grow well in spite of its effects. Municipalities may inject certain salts into their water system to overcome the damage to iron pipes caused by acidic water. Most water companies will supply an assay of their water quality, including the percentages of dissolved salts. Using this assay as a guide, the cycad grower may then add the proper chemical reagents to improve the water quality for the plants.

Water may be delivered to cycads in several ways. Hand watering is probably the best system for potted plants as it allows watering of plants individually. Watering by hand also allows observation of each plant's condition as it is watered, so that infestations or other problems may be noted.

Sprinkler systems of one type or another are probably the most popular means of garden irrigation and work very well for watering cycads. Sprinkler systems not only water the plants but keep leaf surfaces free of dust and dirt. Sprinkling is best done in the evening or early morning when the absence of heat and wind minimizes water loss caused by evaporation. The addition of an automated controller to the sprinkler system simplifies watering and allows one to be absent during scheduled irrigation. The controller makes watering in the early morning or late night possible without inconveniencing the gardener.

Water shortages and restrictions have caused drip irrigation systems to become more popular. These systems slowly deliver water to the plant through small plastic tubes arranged around its base. Drip irrigation has the advantage of watering with minimal loss through evaporation. The main disadvantages are the installation and the somewhat unsightly exposed tubing. Use of mulch with drip irrigation can accomplish two things: it can cover the network of tubing while reducing surface evaporation.

Fertilizer

Generally, soils contain most of the elements essential for plant growth. Soils vary greatly, however, and sometimes fail to supply a sufficient quantity of the nutrients required for good growth in cycads. Cycads and plants in general continually remove these nutrients from the soil. If they are not replaced on a regular basis, the soil becomes impoverished and plant growth is impaired. The application of fertilizer, either organic or inorganic, replaces these lost nutrients.

Proper fertilization of cycads is important to both their growth rate and their health. Cultivated cycads grow much faster than their wild counterparts. As a general rule, most cycads will grow twice as fast with a good fertilizing schedule than those without one. This rapid growth rate is the result of constant availability of water, but perhaps even more importantly the availability of nutrients and trace elements necessary. Healthy, well-fed cycads produce leaves and cones more often than plants that are not fertilized. Robust, fast-growing plants are generally healthier than their weaker, slower growing counterparts and are more resistant to disease and insect infestations.

Fertilizing is a simple process and one that reaps great rewards for cycads. There are two classes of fertilizers: chemical or inorganic, and natural or organic. Organic fertilizers are generally various types of animal manure that are spread as mulch or worked into the surface of the soil. Manures usually contain small amounts of the necessary plant nutrients and therefore do not promote rapid growth, but they contain many beneficial bacteria necessary for proper soil development. Cow and chicken manures must be composted before they are used, otherwise burning of the roots may occur. This burning is caused by the high percentage of nitrogen found in these two manures. Other popular organic fertilizers are blood meal, bone meal, and hoof and horn meal. Organic fertilizers often smell bad and attract flies or other animals. Organic fertilizers also require bacterial decomposition to produce the inorganic nutrients that can be absorbed by plants. This bacterial action takes time, so organic fertilizers are slow to show their effect on plant growth.

Chemical fertilizers are identified on their container by three numbers, the ratio of nitrogen (N), phosphorus (P), and potassium (K), for example, 10-8-6 or 20-20-20. These three elements are the macronutrients, those required in large quantities by growing plants. Other nutrients required in smaller amounts, such as copper, iron, and manganese, are referred to as micronutrients. Micronutrients are also important to healthy plant growth and should be supplied along with the macronutrients when fertilizing. I have found that a balanced fertilizer, one with equal amounts of nitrogen, potassium, and phosphorus, plus trace elements, serves cycads best. Fertilizers high in nitrogen tend to produce long, weak leaves that do not hold up well during windy periods.

Chemical fertilizers are easier and cleaner to apply than manures. They also deliver a known quantity of macro- and micronutrients. Chemical fertilizers can be applied by dissolving them in water and then injecting the concentrate into the water source for the sprinkler system, or by the use of a watering can for smaller areas or potted plants. One must keep in mind that inorganic fertilizers are soluble salts, and these combined with a water supply that is high in dissolved salts can cause problems. Follow the manufacturer's recommendations when mixing a soluble fertilizer and never apply it at greater than the recommended strength. Granular formulations can be applied by broadcasting them on the garden soil. Care must be taken when using granular fertilizers so that they are not accidentally thrown into the crown of a cycad. These fertilizers are generally quite strong and have been known to damage or kill the apex of a cycad stem. Granular fertilizers are generally classed as either quick or slow release. As the name implies, quick release fertilizers become available as soon as moisture is supplied. Slow or timed release fertilizers are formulated so that they dissolve or break down over a period of 1–9 months or more. Slow release fertilizers, especially those that release their nutrients over a longer period, require moisture, heat, and bacterial decomposition to make the nutrients available to the plants.

Fertilization should only be done during the growing season, which is usually spring and summer. Once-a-month application is not too often if it is only applied during the growing season. In areas with cold winters, fertilization should be withheld about 1 month prior to cold weather and not resumed until spring. In areas with year-round growing conditions, no break in the fertilizing schedule is necessary. I use a 9-month slow release formulation so that I can fertilize once in the spring, and the garden receives nutrients throughout the remainder of the growing season.

Nutrient Deficiencies

Nutrient deficiencies in cycads generally manifest themselves as leaf problems. Emergent leaves that are yellow or white instead of green generally indicate a deficiency in manganese. As manganese deficiency progresses, new leaves emerge that look withered or burned. Iron deficiency, like manganese, generally appears first on the new leaves as chlorosis, yellowing of the leaf tissue. Leaves that are light green or yellowish generally indicate a deficiency in nitrogen. This deficiency can be quickly corrected by the application of ammonium nitrate, followed by watering. A yellow band around the margin of the leaflets indicates magnesium deficiency.

Leaf manifestations of nutrient deficiencies, except those of iron and nitrogen, are usually irreversible. Applications of iron or nitrogen to plants deficient in those nutrients will generally begin to turn leaves green in a matter of days. When deficiencies of manganese or magnesium are corrected, affected leaves will not recover but new leaves will emerge normally.

Whenever there is a suspicion that nutrient deficiencies exist, the best course of action is to have a soil laboratory analyze a sample of the soil. The report will show what nutrients are at low levels, providing a basis for correcting any deficiencies. Maintaining good drainage and aeration of soil, and providing proper watering and fertilizing at optimal pH, should protect cycads from most nutritional deficiencies. Correction of nutritional deficiencies should be a last resort. Prevention of deficiencies is always preferable to their treatment.

Pests and Diseases

There are relatively few pests that attack cycads. Some of them are able to cause serious damage or complete destruction of a cycad whereas others may inflict only minor damage. Pests may be divided into three groups, depending on which part of the cycad they attack: stems, seeds, or leaves. The majority of the pests are insects and are seasonal, have life cycles closely adapted to the growth cycle of cycads, and are generally very restricted in their distribution.

Pests of Stems

There are four species of weevils, which are beetles, that are known to attack the stems of cycads. They are significant pests, and heavy infestations have been known to kill entire plants. Even minor infestations can completely destroy the apex of a cycad stem, thereby limiting further growth to basal offsets. These weevils seem to be found wherever cycads grow naturally. The grubs, or larval form, of these weevils tunnel through the cycad stem, inflicting great damage and allowing fungal infections to follow in their path. Larvae are legless and have a cream-colored body and a glossy brown head. Adults are seldom seen and apparently only visit the cycads to lay their eggs. These weevils, because of their tunneling habit, are extremely difficult to control.

In Australia, the *Macrozamia* weevil (*Tranes internatus*) is very destructive. Adults are black to blackish brown, have numerous raised longitudinal ribs on their wing covers, and are about 12 mm (0.5 in) long. This weevil has also been implicated in attacks on Australian *Cycas* and *Lepidozamia*. The *Macrozamia* weevil has also been known to be very destructive to various species of *Encephalartos* in gardens, including ones in the United States. The *Encephalartos* weevil (*Phacecorynus funerarius*) inflicts damage similar to that of the *Macrozamia* weevil. Adults are black, smooth and unmarked, and about 12 mm (0.5 in) long. Another South African weevil, *Calandra sommeri,* has been reported to infest *E. altensteinii.* Adults are brownish, have a series of dotted lines on their wing covers and black markings on the thorax and abdomen, and are about 20 mm (0.8 in) long. The *Zamia* weevil (*P. zamiae*) was first reported attacking cultivated zamias in Europe. Adults are black with red spots on their wing covers and a velvety black oval spot on the thorax.

Some years ago I received a shipment of cycad stems from South Africa that had been vacuum fumigated with methyl bromide by the U.S. Department of Agriculture. Subsequently, I discovered live larvae in some of these stems that I had to kill manually. I am personally aware of two species of these weevils that have been transported internationally in cycad stems. When these weevils become established in a region lacking their natural predators, they can produce devastating results. There is a botanical garden in California that was infested with these weevils through imported cycads. More than 20 years later, efforts are still being made to eradicate them. All imported cycad stems should be kept under close observation for at least 6 months. During this time, the stems should be closely inspected for any evidence of borer holes, and if found, care must be made to eradicate the infestation.

In many tropical areas, termites are abundant, and they have been known to damage cycad stems. They are usually found feeding on dead or dying sections of cycad stems. When mature cycads are transplanted, their roots are often large and woody. Before these damaged roots can start new growth, termites sometimes attack them. Infestations may begin in dead or dying roots, but termites will sometimes tunnel into living plant tissue, causing extensive damage or eventual death of the cycad. Treatment of termite infestations is difficult. If the insecticide chlordane is available, it can be used as a drench on the soil surrounding the cycad trunk. Chlordane has a long residual effect that can protect against termites for many months, but it has been banned in most countries. In extreme cases it may be necessary to excavate or remove the cycad for treatment.

Pests of Seeds

In South Africa, small weevils of the genus *Antliarhinus* attack the seeds of many species of *Encephalartos.* The best known of these is the cycad weevil, *A. zamiae.* The long rostrum or snout, three times the length of her body, easily identifies the female. Several other species of *Antliarhinus,* especially *A. signatus,* are also known to attack cycad seeds. These weevils drill through the outside of the developing seed, then deposit several eggs within it. The eggs hatch into small grubs that will completely consume the storage tissue. In some years these weevils can eat the entire seed crop. The infested seed usually shows no outward sign of the infestation. Infested seed is lighter and can be separated from good seed by water flotation. It is extremely important that infested seeds not be shipped to other countries, especially those with native cycads. There is no known control for *A. zamiae* or *A. signatus.*

Pests of Leaves

There are several insect pests that attack cycad leaves. They can be divided into two groups: sucking insects and chewing insects. Sucking insects include scale insects, mealybugs, and aphids. Spider mites are arachnids that also damage leaves by sucking. Chewing insects include butterfly and moth larvae (generally known as caterpillars), grasshoppers, and beetles. In addition to arthropod pests, slugs and snails may attack cycad leaves. All these pests inflict damage to the leaves of cycads but are generally not a threat to the plants' survival.

Scale Insects. The shell that covers and protects them can readily identify scale insects. The insect is sheltered beneath this shell, which protects it from weather and most predators. The scalelike covering can be hard, waxy, or cottony, and black, brown, red, or white. Scale insects in their adult form are stationary with only their larval stage, known as crawlers, able to move about the leaf surface. These insects generally are found on the underside of the leaflets, giving them added protection. Under the cover of its shell, the scale insect feeds by sucking the sap of the plant. Some scale insects are phytotoxic, and a yellow spot develops around the area where they are feeding (Plate 20). When scale crawlers attack emergent leaves, the leaflets become very distorted from the effects of their feeding. Often, scale infestations are not easily detected, especially when the insects are harbored among the old leaf bases on the cycad's stem.

In 1994 a scale insect (*Aulacaspis yasumatsui*) was introduced from Asia to the area of Miami, Florida. It was doubtless introduced to Florida by way of plants imported from either China or Thailand. By 1996 this scale had spread throughout most of Dade County. Its preferred host is *Cycas* though there have been minor infestations observed on *Ceratozamia, Encephalartos, Macrozamia,* and *Zamia.* Unlike other genera and species of scale insects, *A. yasumatsui* literally encrusted entire leaf crowns of *Cycas* in Miami and Coral Gables. It soon became clear that this was a previously unencountered and dangerous pest. This scale insect has killed thousands of cycads in the Miami area. Attempts at control by spraying insecticides and oils were only marginally effective. Reinfestations occurred almost at once and the condition of the cycads continued to decline.

The Montgomery Botanical Center, Fairchild Tropical Garden, U.S. Department of Agriculture, and Florida Department of Agriculture have cooperated in trying to find a way to eliminate, or at least control, infestations of *Aulacaspis yasumatsui.* Entomologists were sent to Thailand to search for a natural predator that could be introduced as a biological control agent. One was found that appeared promising, and it was introduced into Dade County for testing. Two of the introduction sites were the Montgomery Botanical Center and Fairchild Tropical Garden. Unfortunately, the degree of control was not sufficient to eradicate the scale insect, which continues to be a major problem.

Control of scale insects is usually not too difficult. Oil sprays are very effective, but their application must be closely monitored so that leaf burn does not occur. Oil should be applied in late afternoon or on overcast days to prevent leaf burn. There are also a number of insecticides that provide good control of scale insects. These should be applied at least three times at 2-week intervals to give proper control. The first application will kill most of the adults, and the second and third will kill crawlers as they hatch. The second and third applications are necessary because insecticides will not normally kill eggs.

Mealybugs. One of the common insect pests of cycads are mealybugs (*Pseudococcus*). They are generally found on cycads growing in deep shade, as houseplants, or in greenhouse culture. Macrozamias, because of the way they produce their leaves one after another, make good hosts for mealybugs. The insects infest the crown where the leaves are emerging and can cause browning or distortion of the new leaves. Mealybugs are easy to control using the same procedures for scale insect eradication.

Aphids. Aphids are seasonal and generally occur in the spring as new leaves are being produced. The damage they inflict is usually minimal unless a heavy infestation occurs. During heavy infestations, newly emerging leaves can sometimes become distorted or stunted. Control is easy with a number of commonly used insecticides, or the infected leaves can be sprayed with a strong stream of water, which will dislodge the aphids.

Spider Mites. So called because they have eight legs and are arachnids rather than insects, spider mites are sometimes found attacking cycad leaves. Mites feed by sucking sap from the leaves, and heavy infestations can severely affect their host. Spider mites form colonies on the underside of cycad leaves and move about on a network of fine webs. Warm, dry weather generally allows rapid reproduction of spider mites, and their colonies can grow into severe infestations in a matter of days. Control measures should be initiated as soon as an infestation is observed, otherwise serious damage may result.

Spider mite infestations generally occur on distressed plants growing under dry conditions. Cycads used as houseplants, because of the dry air produced by heating or air conditioning, often fall prey to spider mites. Spider mite control can sometimes be difficult. Moving the cycad to a damper site and hosing off the leaves will generally improve the situation, but spraying with a miticide is usually necessary. Two or three applications of miticide over a period of 4–6 weeks will usually eradicate the infestation.

Caterpillars. The larval stages, or caterpillars, of some butterflies and moths (Lepidoptera) feed on cycad leaves. These larvae generally feed on the soft emerging leaves of cycads but will often feed on hardened mature leaves as well. During heavy infestations, all the leaflets in a new flush can be destroyed. In Panama I have seen infestations of *Eumaeus minyas* on *Zamia acuminata* and *Z. skinneri* where not only the leaves were destroyed, the emerging cones were also eaten. The leopard moth (*Zeronopsis leopardina*), which is common in KwaZulu-Natal, South Africa, is one of the most destructive cycad pests. They are active during summer when the cycads are producing new leaves. The adults lay eggs on the emergent leaves that hatch within 24 hours. Growth of the larvae is very rapid, and complete destruction of a new leaf flush may take only 3–4 days. The *Zamia* butterfly (*Eumaeus atala*) is frequent in southern Florida, where its larvae attack colonies of *Z. integrifolia* (Plate 21). Other species of the genus *Eumaeus* are found in Mexico and Central America. *Eumaeus* has been known to attack not only *Zamia* but also *Ceratozamia* and *Dioon*. Several other species of Lepidoptera are known to feed occasionally on cycad leaves, though not exclusively.

Studies of the various species of Lepidoptera that feed on cycads has shown that they accumulate quantities of the cycad toxins cycasin and macrozamin. These toxins impart chemical protection from predators to the larvae and also to the pupae and adults. Thus the plant being attacked helps protect the insect attacking it.

Control of Lepidoptera and their larvae can usually be accomplished using contact insecticides. The infestations must be treated as they occur, as preventive spraying is not usually effective. Biological control can be accomplished by spray application of the bacterial spores of *Bacillus thuringiensis*. Formulations of this *Bacillus* are available under a number of trade names and can all be used safely.

Grasshoppers. Grasshoppers, locusts, crickets, and related insects (Orthoptera) can cause a great deal of damage to soft emergent leaves of cycads. Larger insects of this group will even eat hardened mature leaflets. These insects are seasonal and do not often occur in large numbers. Spraying with a systemic insecticide will generally give good control.

Beetles. Beetles sometimes attack emergent leaves of cycads. In Australia, the *Cycas* leaf beetle (*Lilioceris nigripes*) is commonly found in Queensland, where it feeds on emergent or recently mature leaves of *C. media* (Plate 22). Both the adults, which are about 1 cm (0.4 in) long with metallic markings on their wing covers, and their fleshy larvae feed actively on *Cycas* leaves. The upper surfaces of the leaflets are eaten, leaving them white and papery. These beetles often destroy an entire new flush of leaves and must be destroyed as soon as damage is observed. This beetle is also known to attack the leaves of *Bowenia* "Tinaroo" (described under *B. serrulata*).

In rural areas of California a small brown scarab beetle (*Phyllophaga*) commonly known as the May beetle or June beetle, usually attacking leaves of avocado (*Persea americana*), has been observed feeding on emergent leaves of *Encephalartos*. Some damage was noted on the leaves of *Ceratozamia* and *Dioon* as well. This beetle is seasonal and seems to cause the greatest damage in the spring, when cycads are producing new leaves. The beetles appear shortly after sundown and feed throughout the night. The larvae or grubs of these beetles are subterranean and feed on roots of avocados. It is not known if these grubs will feed on the roots of cycads.

Control of leaf-eating beetles is somewhat difficult, especially those that are night feeders. The only known control is application of contact insecticides, or hand picking and destroying the beetles. Because the grubs occur below the surface of the soil, they are more difficult to control. In the past, lead arsenate or chlordane applied directly to the soil proved effective, but these chemicals have been banned in most countries.

Slugs and Snails. Slugs and snails are mollusks, a group of animals that also includes shellfish such as clams and mussels. Slugs and snails are similar in structure and biology except that snails form an external spiraled shell. The presence of either is usually indicated by a shiny mucous or slime trail that marks their travels. Slugs and snails have been known to attack emergent cycad leaves, but they appear to be somewhat selective in their choice of genera and species. In my collection, I have noted that emergent leaves of *Ceratozamia miqueliana* are often completely destroyed by attacks of the brown snail, yet other species of *Ceratozamia* are seldom damaged. Slugs and snails often attack seedling cycads of several genera but especially *Ceratozamia* and *Zamia.* Damage to seedlings often leads to fungal infections that can ultimately cause their death.

Slugs and snails are active at night or on dark, foggy or rainy days. They are usually inactive on bright sunny days, remaining hidden in places protected from sun and heat. Broadcast application of granular baits or spraying of wettable powder formulations generally controls them. Another method of control is the use of beer bait traps. Shallow pans are placed every 3–4.5 m (10–15 ft) in infested areas of a garden, with the edges at ground level. The pans are filled with beer or a mixture of beer and baker's yeast. Slugs and snails climb into these pans and are trapped and killed. These traps should be checked daily and any trapped slugs or snails removed.

Diseases

Cycads are relatively disease-free, with most problems arising from improper horticulture. Diseases of cycads are relatively rare except at the seedling stage. The diseases are caused primarily by fungal or bacterial infections.

Fungal Diseases. Fungal infections generally affect cycad roots but on occasion may also be encountered in the crown of the stem. Crown rot is usually a disease of seedlings and is caused by the potting soil remaining too damp, by insufficient air circulation, or both. The four most common fungi causing damage in cycad seedlings are *Fusarium, Phytophthora, Pythium,* and *Rhizoctonia.* These fungi can attack both the crown and the roots of a seedling cycad. Once seedlings have been infected with one or more of these fungi, it is usually too late to save them. Providing a well-drained potting mix and watering at proper intervals will generally prevent fungal infections from occurring. As a general rule, infection by these fungi can be prevented if the surface of the soil is allowed to become dry between periods of watering. There are several good antifungal preparations available for the treatment or prevention of these fungi. In Western Australia the introduction of the fungus *Phytophthora cinnamomi* into the habitat of *Macrozamia riedlei* has caused the death of many mature plants. This fungus has also caused a great number of losses of garden plants. To my knowledge there is no effective treatment for this fungus.

In southern California the naturally occurring oak root fungus (*Armillaria mellea*) has also been known to infect cycads (Plate 23). Infected plants are marked by the production of patches of mushrooms around their base. The growth of this fungus is generally observed during periods of hot days and cold nights when the aboveground mushrooms are produced. If this infection is allowed to proceed untreated, it will usually result in the death of the plant. Infected plants can sometimes be saved if they are removed from the soil and all infected tissue cut away. The base of the plant can then be treated with fungicide and the stem rerooted. There is no effective way to eradicate oak root fungus.

Bacterial Disease. Cases of bacterial rot in cycads are rare and are generally observed in the root areas or damaged portions of stems of newly collected plants. These can be treated by removing all infected tissue from the wound, then applying an agricultural grade antibiotic or soaking in a solution of chlorine or Physan. The stem can then be rerooted and replanted. Without microscopic examination, it is often difficult to distinguish between fungal and bacterial infections.

Cycads in the Garden and Landscape

Cycads are among the finest accent plants and whether planted as a collection or interspersed with other kinds of plants within a garden landscape, cycads attract attention. Their relatively slow rate of growth and predictable dimensions make them useful in many garden applications. The resemblance of cycads to palms tends to add a tropical touch to any landscape where they are used. Cycads may be interspersed with other plants with tropical foliage, or planted in groups. Group plantings are most effective when specimens of various sizes are used. Mixing of species can be quite effective when smaller plants are used as a border or foreground, and larger plants as the main planting or background. Cycads are often used to good effect on either side of an entrance to a house or garden, or as a centerpiece in lawns. Cycads are particularly effective when used on mounds or among boulders. I have also seen some magnificent plantings of cycads lining a long entryway to a house or garden. Such use requires considerable space and must be limited to those fortunate enough to have large garden areas. Suggested garden uses for cycads are listed in an appendix, Cycads for Particular Purposes.

Most collectors or gardeners cannot afford fully grown cycads, and many species are not available in larger sizes at any price. This means that seedlings or immature specimens must be planted. Research into the ultimate size of the species being planted will be required, otherwise future unsightly tangles will surely occur. Such information is provided in the descriptions in Chapter 8. Extra space should be provided as most species will grow to larger dimensions in cultivation than they do in the wild. Thus there are difficulties when one wants to produce the appearance of an immediate and finished landscape. Smaller plants and seedlings produce a sparse appearance that only time can cure. When planting areas with seedling cycads, it is best to incorporate them with other landscape plants that will give the planting a more finished appearance. Once the cycads have grown to a larger size, the companion plants can be moved. Proper spacing of seedling cycads allows the mature plants to display their full beauty without becoming entangled with their companions.

Since most cycads have relatively stiff and spiny leaflets they should be excluded from areas where this feature could pose a problem. Spiny cycads should not be planted where they will overhang walks, sprinkler valves, faucets, and so on. Sufficient space should be left between the cycads so that they can be properly and easily pruned. Pruning cycads is made simpler and safer by using a long-reach pruner. Such pruners are made of an aluminum tube with a cutting head at one end and a pistol grip that works the cutter at the other. They are available in several lengths, including models that are telescopic. With these pruners the process of reaching to the base of the leaves and cutting them off is made quite simple, and the gardener is protected from injury.

Pots and Planters

Cycads make wonderful container plants that can be used at entryways, on patios and terraces, even inside the house. One of the most important considerations for potting cycads is choosing the correct species for the proposed location. Size, spininess, and flexibility are important, as well as the plant's horticultural requirements. Cycads for areas where there is foot traffic should have leaves that are spineless and flexible. Cycads used inside the house or in shaded situations should be those that naturally occur in conditions of low light such as most species of *Ceratozamia* and some species of *Cycas* and *Zamia*.

Cycads take well to growing in pots and can be maintained for many years in the same container. Being potbound does not usually affect a cycad's health adversely, but it does tend to slow its growth. In Asia, especially Japan and China, cycads are commonly used for bonsai, a practice that produces miniature trees. Some of the miniature cycads produced by bonsai resemble the adults in every respect except for their much smaller size. If a potted cycad is to grow well and rapidly, it must be given a pot with enough volume for its root system to grow properly. Potted cycads should be planted in mix that gives good drainage and aeration. Applications of fertilizer should be made about every 4 weeks during the growing season.

The use of cycads in planters requires the same considerations given to potting. Planters are medium to large containers, used either inside or outside buildings. The most important requirements are good drainage and the proper potting soil. The ultimate size of the cycad and its light preferences are also very important. Using sun-loving cycads in a shaded planter will result in plants with long, unhealthy leaves. Conversely, using shade-loving cycads in a planter that receives too much sun will result in plants with sunburned, yellow, unsightly leaves.

Transplanting Cycads

Cycads may be successfully transplanted any time of the year, but the best time is just before the start of active growth. In temperate climates this is generally the spring, and in more tropical regions, just before the onset of summer rains. Just before periods of growth, even very old and large specimens can be moved with proper care. The water and nutrients stored in the cycad's stem can sustain the plant for some months until it reroots. The larger and older the cycad, the longer it generally takes to reestablish. Large, old plants have virtually no feeder roots near the base of the stem, and the roots encountered during excavation are large and woody. When these roots are severed, they should be cut cleanly, then treated with a mixture of fungicide and rooting hormone before replanting. These chemicals are usually sold in the form of a wettable powder, which when mixed with a small amount of water forms a paste that is easily applied to the ends of the severed roots. The proper application of these chemicals reduces the risk of root rot and speeds reestablishment.

Prior to transplanting a cycad, its crown of leaves should be severely pruned. At least two-thirds of the older green leaves should be removed. Reducing the leaf area reduces the amount of water lost through the leaves, helping maintain the cycad's vigor until it reroots. A few leaves should be left on the plant as they are beneficial to its reestablishment. Often, the remaining leaves, especially in larger and older specimens, will die after transplanting. This is usually not a cause for concern, only the response of the plant to its reduced root system. Once new roots are produced, a new crown of leaves will emerge. The first crown produced after transplanting is usually smaller in both size and number of leaves. Each successive crown will be larger as the root system regenerates, until the normal leaf complement is once more attained. After a mature cycad is transplanted, the first growth produced is often not leaves but a cone. This attempt at reproduction is apparently a response to the trauma caused by the damaged root system.

Several things should be considered before replanting a cycad. If it is not yet mature, one must consider its ultimate size and how it will fit into the landscape in 5–10 years. Other considerations, according to the preferences of the particular species, may include soil type and protection from sun, wind, or frost. Knowledge of the preferred soil is often helpful in avoiding nutrient deficiencies. It is better to prevent such problems rather than to have to correct them.

The planting hole for the cycad should be dug several inches wider and deeper than its root ball. Some loosened dirt is then placed in the bottom of the hole and the cycad positioned so that the soil line of the root ball is equal to the grade of the surrounding soil. The hole is then filled to just below its upper edge. The hole can then be filled with water and the plant gently rocked to remove all air bubbles and settle the soil. The composition of the soil used to fill the hole can be critical in the reestablishment of the cycad. In the past it was generally recommended that soil be mixed with liberal quantities of organic material. More recent findings indicate that this may be unnecessary and in many cases may be detrimental to the proper reestablishment of the cycad. In heavy soils the use of fill amended with organic materials creates an artificial condition in which the roots may never penetrate the surrounding soil. The difference in porosity between the fill and the heavier soil creates a container that inhibits proper drainage and may eventually cause root damage. It is recommended that the same soil removed in digging the planting hole be used as the fill.

After the initial soaking of the root ball to settle the fill in the planting hole, watering should be kept to a minimum. Constant soil moisture is necessary for the production of new roots, but keeping the soil too wet can cause rot in the damaged roots. The application of a layer of mulch around a newly transplanted cycad will help maintain the proper soil moisture. Once active growth begins, the normal watering schedule can be resumed. Complete drying of the soil around transplanted cycads should not be allowed. Because of their shortened and damaged root system, excessive drying may cause damage to developing roots and impede reestablishment of the cycad.

When replanting tall cycads, especially when portions of the leaf crown have been retained that may cause problems during high winds, some sort of stabilizing will be required. This can be done by the use of stakes and wires, or bracing with lumber or rocks. The use of wires or rocks is recommended as they result in less visual intrusion in the landscape than wooden braces. Bracing is usually required for 2–3 years for larger plants to allow the root system to regenerate.

It is generally a good practice to spray transplants with a broad-spectrum insecticide before introducing them to their new site. Follow-up applications of insecticide should be made at least two more times at 2-week intervals. This procedure will protect the garden against the introduction of insect pests from the cycad. Insect control is also beneficial to the transplanted cycad as weakened plants are more susceptible to insect infestations and damage.

CHAPTER FIVE

Propagation of Cycads

There are three basic ways to propagate cycads. The first and most common method is growing them from seed, either wild collected or produced through hand pollination in gardens. The second method is the removal of basal or aerial offsets or suckers (sections of stem), then rerooting. The third method is an experimental propagation method for cycads, tissue culture.

Propagation by Seed

Seed collected from wild plants generally has a greater viability than that produced by artificial pollination in the garden. Seeds from plants in their natural habitat also have the added advantage of genetic authenticity. Seeds from garden plants are not as authentic because garden populations are almost never as diverse as natural populations, thus there is an element of artificial selection when garden plants are used as parents. Also, there is a possibility that hybridization may occur in the garden because populations that are geographically separated in the wild may be brought together through cultivation. Even if care is taken during hand pollination, when insect pollinators are present that can effect pollination, the possibility of accidental hybridization is increased. For these reasons, only seed collected from the wild should be used to establish breeding colonies for the purpose of conservation.

Male Cones

Some difficulty may be experienced in the identification of male cones until familiarity with the particular genus or species is gained. In genera such as *Cycas* and *Dioon* the difference between female and male cones is so great that they are easily identified. In other genera, male cones generally are longer, thinner, and have many more sporophylls of smaller size than female cones of the same species. In the wild as well as in cultivation, male cones are produced more often than females. It takes more energy to produce a female cone. Male plants tend to develop multiple cones more often than females (Plate 5). Male plants that produce more than one cone often form them in succession, the oldest maturing and shedding pollen first, soon followed by the others in sequence. In this manner a single cone, which sheds its pollen in about a week, is followed by several others, so pollen is shed over several weeks. This is important in species with low population numbers and helps ensure that pollen is available when the female cone is receptive.

When the male cone reaches maturity, rapid elongation of the central axis of the cone precedes the shedding of pollen. The elongation separates the sporophylls, exposing the sporangia (pollen capsules) on their lower surface. The pollen capsules split, and the pollen is shed. Usually the pollen falls as a dustlike cream-colored substance. Occasionally, during periods of high humidity as a result of rainfall or greenhouse culture, the pollen is shed stuck together as a small ball the size and shape of the capsule from which it has dropped. When this pollen is moved to a drier atmosphere, it soon reverts to its normal dustlike form. During the period of pollen shedding there is usually an increase in the temperature of the cone, above that of the ambient air temperature. Along with this increase in temperature there is usually the production of an odor that lasts until shedding is complete. These phenomena are considered to be associated with the attraction of insect pollinators.

Collecting Pollen. Pollen can be collected in two ways. By far the easiest method is removal of the cone from the plant. Shortly after cone elongation, pollen will start to be released from the capsules. Pollen shedding starts at the base of the cone and works upward, and from the inside (that portion closest to the cone axis) of the sporophyll to the outside edge. Shedding can be easily detected by gently tapping the cone and watching for pollen to fall. This must be done each day, otherwise much of the pollen will be lost. When pollen is first noted, the cone peduncle should be cut while the cone is held upright. The cone is carried, upright, and laid on a piece of smooth paper. Rougher paper such as newspaper does not work well because it has a surface that can trap much of the pollen. The cone is placed away from drafts and left on the paper 2–3 days as it matures and continues to shed pollen. This process can be helped along either by tapping the cone or running an instrument or fingernail over the surface of the cone. This movement helps free pollen from the capsules and should always be performed over the paper. Total time for pollen shedding may vary from 3–4 days in small cones of *Bowenia* or *Zamia* to as long as several weeks in *Stangeria.* Pollen shedding is more rapid in warmer climates and slower under cooler conditions. This can have consequences for plants native to the Southern Hemisphere that have been moved to the Northern Hemisphere, for example. Quite often, cycads will not adjust to their new location and will continue to produce cones and leaves during the Southern Hemisphere's summer (winter in their new home) or vice versa. This puts the plant in the position of producing new growth in temperatures below what they should be. The result may be stunted leaves and cones that take longer to mature.

The second method of collecting pollen is used when cone removal is not practical, from a display plant or one that is be photographed, for example. Pollen collection will be more time consuming and result in a greater loss of pollen, however. A piece of smooth paper somewhat longer than the cone is taken and a fold 2 cm (0.8 in) wide made along the bottom. With this fold at the bottom and facing the cone, the paper is gently slipped between the leaves until its lower edge rests against the cone peduncle. The cone is then gently bent toward the paper and tapped to release the pollen. The pollen falls onto the paper and slides to the bottom where it is caught in the fold. The paper is then carefully removed and the pollen used or stored. With this method, pollen will have to be collected almost every day during its shedding or much of it will be lost. Care must be taken that the cone is not bent so far that it snaps off.

Storing Pollen. There is considerable disagreement over the period of time pollen will remain viable under refrigeration. Roy Osborne et al. (1991) wrote that in their experiments, cycad pollen stored at ambient temperature degraded slowly and after about 9 months was not viable. More recent experiments have shown that pollen, desiccated and frozen at 0°C (32°F), may be viable as long as 3 years or more. Frozen *Cycas* pollen was reported to have produced viable seed for three seasons. *Encephalartos* pollen stored in liquid nitrogen, which maintains a temperature of −196°C (−320°F), showed no loss of viability (Osborne 1989). Dried, deeply frozen cycad pollen could theoretically be stored indefinitely, which would be useful for long-term fertilization. Even though scientific data on storage of cycad pollen have not been gathered completely, it would seem prudent to store pollen for future use. There are many collections that contain only a single female or male plant of a rare species in which cones are produced in alternate years. Without pollen storage, these cones are not productive.

As cycads have become better known and more common in collections, cycad pollen banks have been established. These banks are usually operated by an organization that tries to make pollen available to anyone who has a female plant and desires to produce seed. In this way it is hoped that some of the more endangered species may have their numbers increased. Because scientific data are often lacking about the viability of stored pollen, it is advisable to use fresh pollen whenever possible. Frozen pollen should only be used as a last resort. When frozen pollen is used, notes should be kept about the age of the pollen, the method of storage, and the number of viable seeds produced. This information would be valuable in studies of pollen longevity.

In all genera of cycads except *Encephalartos,* seeds do not generally mature unless they have been pollinated. *Encephalartos,* however, always produces full-sized seeds, even if the cone has not been pollinated, in which case the resulting seed is not viable but appears normal in every other respect. In other genera, however, I have found that the introduction of nonviable pollen or incompatible pollen (from a plant with a different chromosome number) can cause seed to be produced that is normal in every respect except that it is not fertile. This often leads to false conclusions about the success or failure of a fertilization attempt. The only proof that fertilization has been successful is the germinating seed.

Female Cones

Female cones of cycads may be divided into two distinct groups: *Cycas,* in which the female cone is composed of a large number of sporophylls resembling modified leaves with ovules attached on either side of the sporophyll stalk, and all other genera, in which true cones are produced. In the latter, each sporophyll has two ovules attached to the inside of the sporophyll, the side closest to the cone axis (Plate 6). These two groups require different pollination techniques.

For pollination of a cycad to take place, pollen from the male cone must be deposited at the micropyle of a receptive female ovule. When the female cone is receptive, a small drop of liquid is secreted at the micropyle of each ovule. Pollen must be transported to the micropyle and trapped in the liquid to effect pollination. Cycads are probably all insect pollinated. Without the insects, it is left to us to do the job. Actually, the absence of insect pollinators from most cycad collections is probably fortunate, as otherwise many inadvertent hybrids could be produced.

The female cone, as in the male, generally exhibits an elevated temperature and produces an odor during the receptive period. Another indication of the female cone's receptive condition is the opening of cracks between the sporophylls. These cracks are usually horizontal between the sporophylls and generally near the apex of the cone, or in some cases at or near the base, or both. Sometimes a vertical crack appears that may or may not run from the cone's base to the apex. In others, all the sporophylls are separated by a slight elongation of the cone axis. In almost all cycads, the cracks close at the end of the receptive stage or shortly after pollination has been accomplished.

In some species of *Encephalartos,* the cracks are not large enough to be seen easily. The sense of touch can be used to discover if the sporophylls near the sterile cap are loose. In some species of *Encephalartos,* when the cone is receptive, the color of the outside margins of the female sporophyll brightens, turning from dull medium green to bright green or chartreuse.

Dioon does not show its receptive stage well. Dioons from the eastern coast of Mexico have female cones in which the two basal rings of sporophylls lack the heavy tomentum that covers the rest of the cone. When a cone becomes receptive, these glabrous, bright green sporophylls open, giving access to the small beetle that is their pollinator. The beetles carry the pollen through these ports at the base of the cone and transport it upward to the ovules. Dioons of central and western Mexico have female cones in which all the sporophylls are encased in a dense tomentum, even those at the base of the cone. Close observation will disclose a spreading of the apex of the lowest sporophylls until bare flesh can be seen at their base. This smooth channel leads directly to the interior of the cone. Generally, this opening must be viewed from above as it is not apparent when viewing the cone from the side.

Pollination

Cycas, which has a very open female cone, is easiest to pollinate. This can be accomplished by simply dusting pollen onto the cone when it is receptive. If pollination is successful, the seeds will grow to full size. All the other cycad genera have a more conventional female cone. In many of these, detection of the receptive stage and introduction of pollen into the cone can be quite difficult. In my experience, when female and male plants of the same species are garden or greenhouse grown under the same conditions, they generally become receptive at the same time. When the male cone starts to shed pollen, the female is generally receptive even though there may be no outward indications. Therefore, pollination attempts should be started on the female cone when enough pollen has been collected. It is best to pollinate when the female shows signs of receptivity, but sometimes these indications are not apparent. There are two ways in which to administer pollen to the female cone, either dry or in a liquid suspension.

Dry Pollination. Since the object is to reach as many ovules as possible with pollen, the pollen must be introduced into the openings between the ovule and the cone axis. This can be attempted by removing a sporophyll near the apex of the cone and either blowing (as with some sort of dust gun) or pouring dry pollen into these spaces, then tapping the cone to shake the pollen to its base. Although this procedure will work, the percentage of viable seed usually produced suggests that it is not especially effective.

If the cone has cracks open between the sporophylls, as is generally so in *Macrozamia,* a dust gun can sometimes be used effectively to blow pollen over the entire exterior surface of the cone. This method also has its limitations in genera that do not open as completely as *Macrozamia.* In *Ceratozamia, Lepidozamia,* and *Zamia,* the most effective method I have found is to cut off the cone apex, exposing the openings around the cone axis. Pollen is then poured into these openings and the cone tapped to carry the pollen to the base. Pollen can also be blown into these openings with good effect.

Dioon requires special treatment because the conformation of the cone does not allow the apex to be cut off. The tops of *Dioon* cones are thickly covered with tomentum that reliably excludes pollen from entering the upper portions of the cone. Attempts to introduce pollen through the openings at the base of the cone usually give poor results. Excellent pollen penetration, however, can be accomplished by separating three or four of the sporophylls at the apex of the cone. They have to be forcibly separated because of the thick, interlocking tomentum. When the white flesh can be seen at their base, the terminal sporophylls are grasped and bent from side to side until they snap off at the base. Once broken, they can be pulled out, exposing the openings around the cone axis. Pollen can then be poured into the opening, and the hose of a tire pump or other air pump inserted into the opening. While grasping the terminal sporophylls tightly around the hose, sealing it in place, the pump is exercised, blowing pollen through the cone. If done successfully, pollen will be seen to exit through the openings at the bottom of the cone, at which time pumping is stopped. The hose is removed, and the sporophylls that were broken from the apex are replaced, sealing the opening against insects and water.

Wet Pollination. A water suspension of pollen is used when penetration of the female cone by dry pollen is difficult because of the small size of the openings or when the total amount of pollen available is very small. About 30–60 ml (1–2 ounces) of water is placed in a clean container with a small amount of surfactant (wetting agent, such as liquid soap) to break the surface tension. Pollen is poured into the liquid and thoroughly mixed with it. The pollen-water mixture can be used as is for small cones or extended by the addition of more water for large cones. It may be applied with an eyedropper to very small cones such as *Zamia pygmaea* or poured from the beaker into an opening made by the removal of a sporophyll near the cone apex in large cones. Where the amount of pollen is very small, wet pollination is helpful in spreading it evenly through the entire cone. The use of the surfactant is important because without it the water will often simply run off the exterior of the cone without any penetration.

If pollination has been successful, the ovules begin to enlarge within a few days. Often, the seeds enlarge to such an extent that the sporophylls are forced apart, partially exposing the seeds within the cone.

Maturation of Seed

Generally, it takes about 8–9 months for a female cycad cone to mature and start shedding seed. A few of the tropical *Encephalartos* species can mature in 4–6 months. Some species of *Dioon,* especially those from the western coast of Mexico, may take almost 2 years. When a cone reaches maturity, the central cone axis starts to decompose from the apex to the base. Complete decomposition and its associated seed shedding take 10–30 days.

When the seeds are first shed, the sarcotesta (the colored flesh on the outside of the seed) is quite firm. As the sarcotesta ripens there is usually a color change and a softening of the tissue. It is at this point that the seed should be cleaned. The sarcotesta is thought to have an inhibiting effect on germination. Therefore, it should be removed before seeds are planted. Some seeds, including those of most species of *Ceratozamia, Dioon,* and *Macrozamia,* are easily cleaned. Others such as those of *Cycas* and *Zamia* are difficult to clean because they have a very sticky, rubbery sarcotesta that almost defies removal. Cleaning *Zamia* seeds will surely test anyone's patience! More recently, the cleaning of more difficult seed such as *Zamia* has been made quite simple. There is an enzyme called Klerzyme that when mixed with water, then poured over ripe seeds, will completely digest the sarcotesta in 7–10 days. The digested sarcotesta can then be simply washed away with water. After several years of using this enzyme to clean cycad seeds, no adverse effects to the seeds have been noted.

It is good to dissect two or three seeds to see if the coiled suspensor and embryo are present. The seeds of some species of cycads are ready to germinate at the time of shedding and should be planted at once.

Planting Seeds

Most cycad seed is not ready to plant at the time of shedding. Many genera such as *Cycas, Dioon, Encephalartos,* and *Lepidozamia* must have a developmental period of several months after they are shed. During this time, the embryo matures and the seed is then ready to germinate. Other cycads such as *Microcycas, Stangeria,* and some zamias often have fully developed embryos at the time they are shed, and *Microcycas* seed has been known to germinate while still in the cone. All cycad seeds that have a developed embryo when shed should be planted immediately. These seeds do not store well and will soon dehydrate so much that they will not germinate, or if they do, they will produce weak seedlings.

Cycad seeds are longer than broad, or if rounded, they are slightly flattened. This conformation causes the shed seeds to be aligned so that the embryo is horizontal to the soil surface. It is in this position that the seed normally germinates in nature.

In cultivation, cycad seeds are usually germinated in flats of well-drained mix. Sponge rock, course sand, or agricultural pumice work well with nothing else added. It is a good practice never to use soil for seed germination. Soil contains an abundance of bacteria and fungal spores that can prove fatal to the germinating seed. Basically, all that is needed is a medium that will hold moisture without being too wet. The seeds are pressed into this material, lengthwise, to a depth of about half their diameter. Some growers insert the chalazal end of the seed into the medium, with the micropylar end elevated, but this has not worked well for me. An application of wide-spectrum fungicide is often worthwhile to minimize fungus growth that might damage the seeds before they germinate.

Bottom heat at about 27 °C (80 °F) will hasten seed germination dramatically. The radicle will rupture the end of the sclerotesta (stony seed coat) and then turn toward the soil. Once the tip of the radicle touches the moist germinating medium, a root is formed that penetrates the surface.

A close watch should be kept on the germinating seeds to ensure that the rapidly growing root does not penetrate the medium in the flat and exit through the drain holes. The root is very brittle at this stage and can be easily broken. Injury to the root at this point can allow entry of fungi, which could destroy the seedling. Dipping the broken root end into a fungicide powder such as captan and returning them to the flat can usually save injured plants. After about 2 weeks the wound will usually heal and a new root tip will be formed. Generally, when the root length reaches about 2.5 cm (1 in) the seed should be potted.

Potting Seedlings. The germinated seeds do best when placed into a deep pot that allows the taproot to develop. Cycad seedlings will grow more rapidly in a deep pot than a shallow one. Planting in a shallow pot will force the root to spiral around at the bottom, and as it enlarges it will cause the crown to be pushed out of the soil. During the first month it is very important not to allow the potting medium to become overly dry. When the root is very short, drying of the soil surface can damage it. The taproot will grow rapidly, and watering will not usually be critical after the first month. Shortly after the sprouted seed is potted, the cotyledons or seed leaves will crack open and the first true leaf will emerge. During the first year or two, the seedling will generally produce only single leaves during each growth cycle. Even at this early stage of development, leaves are formed in a spiral arrangement. Unlike adult plants, seedlings will often have several growth cycles per year, each time forming but a single leaf. At approximately 2 years of age, the seedling will produce its first set of multiple leaves. Only two or three leaves will be formed at first, but each succeeding leaf emergence should show an increase in the number produced. There will be a constant increase in the number of leaves produced until the cycad reaches maturity. At that time the maximum number of leaves for that particular species will be attained. From that time, leaf production will generally take place each year, or alternate with coning.

Seedling leaflets are usually quite different from those of the adults. They may be wider or narrower and often exhibit numerous marginal spines or teeth that may disappear in the mature leaflet. Anywhere from 3 to 10 years is necessary to attain adult leaves.

The seed will remain attached to the seedling for a year or more after germination. It should not be removed but allowed to remain on the seedling until it is naturally shed. During this time the endosperm tissue remaining within the seed helps nourish the seedling until its root system has been established. The coralloid roots now begin to form at the juncture of the radicle and the root. These roots contain cyanobacteria that fix nitrogen from the air. In this way the developing seedling is not only nourished by the endosperm but also by nitrogen fixation in the coralloid roots and nutrients absorbed by the taproot and feeder roots.

Propagation by Offsets and Cuttings

The practice of removing offsets (often referred to as suckers) or portions of a cycad stem and rerooting them has been a common practice for many years. Most arborescent cycads produce offsets at the base of the stem. These may be excavated, carefully detached, and rerooted to produce a new plant. These basal offsets generally have their own root system and can be easily reestablished. I use a chisel-like instrument with a thin, wide blade and a rubber or wooden mallet to cut offsets free from the mother plant. Once detached, the area on the offset that was attached to the mother plant is treated with a fungicide to minimize rot. Although the offset usually has its own root system, I usually cut these roots back to the base of the offset and treat them with fungicide. This is done because the root system is usually damaged during removal of the offset, and bent or broken roots can allow entry of fungal infections. Sometimes the offsets have a crown of leaves, and the number of leaves should be reduced to prevent dehydration of the offset. The offset is then placed in pumice, sponge rock, or sharp sand until new roots are formed. The best time of the year to remove offsets is at the start of the growing season. Because of the warm weather and the plant's natural growth stimulus, new roots are soon formed. I generally treat the cut area on the mother plant by applying tree seal to prevent the entry of fungal infections.

Branches or stem cuttings are treated similarly to offsets. Branches are generally the result of damage to the cycad stem and when removed usually have no roots of their own because they are attached to the vascular system of the main stem. Removal is usually accomplished by cutting off the branch or stem section, treating the cut end with fungicide, and potting in the manner described for offsets. Branches and stem cuttings usually bear a crown of leaves, and some of these should be left attached as they will assist in root formation. Branch and stem cuttings usually take longer to produce roots than offsets.

In 1985, while working in a cycad propagation research program at the Los Angeles State and County Arboretum, Arcadia, California, I investigated the possibility of growing cycads from leaf cuttings. I removed recently matured leaves, treated the cut ends with fungicide and rooting hormone, and planted the cuttings in sterile medium in a heated humidity chamber. After several weeks a number of the leaf cuttings formed callus, some of which eventually differentiated into roots. The callus on some leaves attained a diameter of more than 5 cm (2 in) and produced massive root systems more than 30 cm (12 in) in diameter. Funding was lost and we were not able to carry our research to its hoped for conclusion, the production of a plant. We were surprised to find that leaves that were too long to fit into the humidity chamber could be cut into two or three sections, and each one would root. I have no doubt that the leaves with callus formation and roots could have been treated with growth regulating chemicals that would eventually have induced bud formation.

At Cycad 99, the Fifth International Conference on Cycad Biology, there was a report from the Durban Botanic Gardens, South Africa, that a successful attempt had been made at producing a cycad from leaf cuttings (Dalzell 2002, Osborne and Dalzell 1996). If this procedure can be standardized so that most attempts are successful, it will allow seedless propagation, using only leaf cuttings from wild populations.

In 1965 I took some leaf bases from a specimen of *Encephalartos villosus* that had been received with the entire center of the stem rotted. In those days it was thought that there was a dormant bud at the base of each leaf base that could be activated by damage to the stem. This supposedly explained why buds formed wherever a stem had been damaged in some manner. The leaf bases from this *E. villosus* had in some cases had half to two-thirds of the base rotted away before they had callused. Often, cycad stems will rot and then callus, sealing off the unrotted portion. These scales were removed, sterilized by dipping in a 10% solution of bleach, then placed in a tray on sponge rock with bottom heat and overhead misting. In about 3 months, callus formed at the base of these scales, and eventually roots were produced. After several more months some of the scales produced buds from the basal callus. The buds eventually produced a leaf and were then potted individually. These plants all grew normally and eventually developed into large specimens. This experiment proved to me that there were no dormant buds located at the base of the stem scales, and that a cycad stem is capable of initiating a new growing point in almost any area where it is damaged.

Propagation by Tissue Culture

Tissue culture is a propagation technique that must usually be performed in a laboratory under sterile conditions. Research into tissue culture as a means of increasing the numbers of rare cycads met with somewhat limited success until a breakthrough was made in 1984. Since then, two species of *Ceratozamia, C. hildae* and *C. mexicana,* two of *Zamia, Z. pumila* and *Z. vazquezii,* and *Dioon edule* have successfully made the transition from sterile medium to potted plant.

There are obvious advantages to using tissue culture for the propagation of rare cycads. Consider *Encephalartos woodii* as an example. Only a single male plant of *E. woodii* has ever been found. Because no female plants are known, propagation by seed is impossible. The only means of propagating *E. woodii* through the years has been the removal and reestablishment of basal offsets. After 100 years of propagation, only about 300 plants have been produced. By using small amounts of plant tissue, such as leaflets from an emerging leaf, it may be possible to produce large numbers of new plants without damaging the parent. Once this process is perfected, it could bring extinction to a halt and reverse the decline of some extremely endangered cycads.

Tissue culturing, as the name implies, is the regeneration of a plant by starting with a small piece of living tissue. Plant tissue that is undergoing rapid cell division, root tips or emergent leaves, for example, is detached from the plant, sterilized, then placed on a sterile nutrient medium in containers. The cultures are maintained in darkness at approximately 25°C (77°F) to induce the formation of callus. This undifferentiated callus continues to grow and from time to time is cut into smaller pieces and returned to the medium for more growth. This process is continued until the desired number of callus clumps, called explants, has been produced.

The explants are then grown on nutrient medium for several more months until cell differentiation into organs such as the suspensor and proembryo takes place. The explants are maintained under these conditions until somatic embryos are produced and eventually germinate. At this point the containers are moved into a lighted area and maintained until root and leaf formation has taken place. After the first leaf has matured and a root has been produced, the explants are removed from the sterile container and planted in sterilized agar. The transfer from petri dish to open pot is a critical one, and the young plant must be maintained in a humidity chamber during the first 4–6 weeks. The plants are then slowly acclimated to a drier environment. During this process of acclimation, propagations may be lost to fungal infections. Research is underway to reduce the losses (averaging 30–40% or more) caused by the transition from sterile medium to potting soil. Once this problem has been solved, mass production of many rare and endangered cycads will be possible.

One of the interesting facets of tissue culture is that a specialized growing medium is required for the propagation of each cycad genus. The callus is formed in a solution, and the explants are then transferred to agar plates. A medium in which *Ceratozamia* grows is not successful for *Dioon* or *Encephalartos.* This means that research must be done to produce a growing medium that will work for each genus. This is a time-consuming and painstaking process that can take months or even years to perfect. Richard Litz of the Tropical Research and Education Center, University of Florida, Homestead, has perfected media for culturing *Ceratozamia* (Plates 24, 25) and *Zamia* (Chavez et al. 1992, Litz et al. 1995). He is working on developing growing media for *Encephalartos.*

CHAPTER SIX

Conservation and Protection of Cycads

The mounting interest in cycads has resulted in the plants becoming popular subjects of research, collecting, and landscaping. The public has become aware that cycads existed on the earth at the same time dinosaurs roamed its surface more than 200 million years ago. Though the term "living fossil" is somewhat a misnomer, since the taxonomic diversity of cycads now is apparently as great as it has ever been if not more so, its application to cycads as a group has no doubt sparked the interest of many who were previously unaware of cycads. Meanwhile, the growing interest in conservation in general, of endangered species in particular, has focused attention on the disappearing animals and plants. The cycads are disappearing.

Alas, the desirability of cycads to adorn gardens, or to form collections, has contributed to their destruction (Plate 26). For example, in Mexico hundreds of thousands of mature plants have been exported to the United States and Japan for the nursery trade, and in South Africa the popularity and cost of the plants has resulted in a thriving black market, causing the destruction of colonies of the more desirable species. Unchecked, this trade has led to extinction in the wild of several of the more popular species.

Loss of natural cycad habitats through urbanization, highway construction, clearing for agriculture, and building of dams has been even more damaging. The greatest threat to cycads, however, has been clearing of forest habitats by indigenous people who do not know the value of the plants destroyed (Plate 27). This damage is no less destructive because it has been gradual and thus insidious, though its pace in many cycad habitats has unfortunately been on the rise. Its end result is the eradication of habitat along with the organisms living there. If these people were given a choice between cutting down their native cycads or earning money by collecting and selling seeds and thus preserving cycad populations, most would choose the latter. Such a conservation operation could ensure the protection of wild plants while making propagation material available for research and commerce.

In the evolutionary process, extinction is one of the natural processes, occurring when a plant group is unable to adapt to a changing environment or fails in competition with plants that are more adaptable. More recently, however, the major cause of extinction is not a natural process. Plants and animals do not drift naturally toward extinction—they are driven to it. In one fashion or another the primary agent of extinction today is man. The human race is exceedingly clever at expanding its range and numbers, equally clever in modifying the environment to fit its own short-term needs, and in doing so destroys hundreds of species in the process. Sadly, this destruction gains momentum with each passing year! On April 2, 1933, David Fairchild, renowned botanist, plant explorer, and conservationist, signed the guest book at Harvard University's botanical garden in Cienfuegos, Cuba, "no function of the science of Botany is more important than that which has to do with the saving from extinction the existing forms of plants which are gradually disappearing from the globe." This remark is just as true now as it was then.

In Situ Conservation

Conservation of endangered plants in their natural habitats, *in situ,* is the ideal method of conservation. When it can be accomplished, not only is it least stressful to the species in question, it also preserves all the other species

—other plants, animals, soil microorganisms, and so on —that live in the habitat. The major problems in conserving plants *in situ* are the acquisition of the land and then ensuring the safety of the organisms. The cost of the land and the subsequent expense of policing it to deter vandalism or theft can amount to more than local governments are able to afford.

South Africa has been a leader in the establishment of preserves for indigenous cycads and in this respect should serve as an example to other countries. Even with their preserves and a comprehensive set of laws to protect cycads, however, South Africans are faced with a cycad black market that has developed into an uncontrolled drain on the cycad populations, even those within preserves (Giddy 1984). There are not many ways to curtail illegal collection of cycads. Conservation officials must fully support the botanical gardens, collectors, and nurseries that propagate cycads for sale to the public. Once the legal cycads are available in a variety of sizes and quantity sufficient to satisfy demand, the black market cannot survive. Also, conservation values are fostered by continuing public education on how precious the remaining cycad populations are to science and posterity.

Rescue Operations

Rescue of endangered species from threatened habitats has been tried on a limited scale in several countries. These salvage operations, though well intentioned, have usually proven ineffectual because of the uncooperative attitude of officials involved for the legal exporting of specimens. Although it is desirable for salvaged plants to be replanted in the country from which they are rescued as part of habitat restoration, as a practical matter it would be desirable to allow export of specimens that would otherwise be lost. But in some countries the attitude seems to have been that it is better for the plants to be destroyed than to grant permission for their export.

Countries with agriculturally based economies find themselves faced with the problem of species destruction without the means to halt it. Although officials in charge of conservation of threatened plants have good intentions, most do not have the means available to mount rescue operations, nor the facilities to care for salvaged plants. What is needed is a worldwide rescue network to which projects that affect areas of botanical interest such as dam construction and road building would be reported. The rescue network would notify interested parties such as botanical gardens and collectors. The sale of subscriptions to a newsletter or notification service announcing such alerts could help fund the network. The governments of the affected areas might then fund conservation programs by charging a fee for collection and export permits to the interested parties. In this way valuable plants could be saved that would otherwise perish, and the governments could obtain conservation income from plants that would otherwise be lost. The construction of a dam in Colombia that will flood the habitat of the endemic cycad genus *Chigua,* with its two species, is an example of a conservation crisis that might be remedied through a rescue network.

Ex Situ Conservation

Ex situ conservation, the growing of endangered plants outside their natural habitats, in botanical gardens, private collections, parks, and nurseries, for example, has met with some success. In most cases, however, only one or two plants of a species are grown for display and no propagation is attempted. For *ex situ* conservation to amount to more than the maintenance of a few endangered individual plants, there must be dedication and a commitment of space, time, and money. Sufficient space must be available to grow colonies of particular species, and knowledgeable workers with an interest in conservation must be provided to care for them. A worldwide survey of botanical gardens disclosed that only a few were attempting to propagate their cycads, and those that were usually produced the more common species that are not endangered or much sought after (Osborne 1992).

The Role of Propagation

There are a number of problems that must be dealt with in the propagation of cycads for *ex situ* conservation. The climate of an area where the cycad is grown sometimes must be very similar to that of the cycad's natural habitat. Geographic position itself can be a problem. For example, it has been my experience that some of the species from the Southern Hemisphere never quite adapt to the Northern Hemisphere because they produce cones (and leaves) in the wrong season. The cones often do not become fully mature or receptive because of the effects of cold weather. Humidity apparently plays a role in the reproductive cycle of at least some species from dry habitats. I have been informed that *Encephalartos horridus* will almost never cone in the humid climate of Miami, Florida, whereas in the drier climate of California it cones freely. Most cycads, which are native to areas of summer rainfall, will make the change to a winter-rainfall Mediterranean climate as long as water is provided during summer.

In addition to the difficulty sometimes encountered in cultivating cycads for *ex situ* conservation, research has indicated that all cycads probably have insect pollinators, with wind pollination only accidental. If colonies of cycads are planted for artificial seed production in areas with insect pollinators, it may be difficult to exclude the pollinators. Cross-pollination between *ex situ* colonies in gardens can lead, as it has, to the creation of hybrids in artificially propagated seed. The only way to ensure seed purity of the species being conserved is to obtain seed from plants in their native habitat or to cultivate colonies for reproduction in areas that have no pollinators that can carry pollen from cycad to cycad.

Much has been written regarding adverse effects of seed collection from wild populations of endangered plants. Close examination of the population and reproductive biology of cycads suggests that, on the contrary, seed collection from wild populations should be recommended for their preservation. Individual cycads have a long life span, thus their natural populations do not require a high replacement rate. When wild populations of cycads are studied, it is surprising how few immature plants are seen. My habitat studies indicate that less than 1% of the viable seed produced in wild colonies survives in the form of seedlings past the fifth year. In cultivation, the viable seed can have an almost 100% survival rate. It is obvious that large numbers of plants could be produced through wild seed collection and cultivation (Plate 28). Of course, *ex situ* cultivation may also provide an opportunity for *in situ* restoration of populations through the reestablishment of cultivated seedlings in the natural habitat.

A good example of conservation through cultivation and artificial propagation is seen in the rare Cuban cycad *Microcycas calocoma.* It has been estimated that fewer than 400 plants remain in the natural habitat. The Fairchild Tropical Garden, Miami, Florida, through hand pollination of two cones on their one mature female plant, produced enough viable seed to more than double the world's population of this rare cycad. The Fairchild Tropical Garden then distributed the seeds worldwide to numerous botanical gardens and collectors while retaining a quantity to grow into a breeding colony.

Protection of Cycads

Since the 1960s, cycads and endangered species in general have progressed from relative obscurity to international celebrity. During this time, numerous laws have been passed for their protection, usually on a national level. It was soon discovered that national laws could not stop the flow of endangered species from one country to another. It became clear that proper control of endangered species had to be accomplished at an international level. After considerable research into the varied problems of managing and protecting endangered species, a proposal was made for an international trade agreement. This agreement was to become known as the Convention on International Trade of Endangered Species of Wild Fauna and Flora, more commonly known by the acronym CITES.

CITES was negotiated and signed by 80 countries in Washington, D.C., on March 3, 1973. It was the culmination of almost 10 years of effort, headed primarily by the International Union for the Conservation of Nature and Natural Resources (IUCN), now known as the World Conservation Union. CITES came into effect July 1, 1975, when the tenth country ratified it. CITES has been quite successful in controlling commercial trade in endangered species, but much of the loss in numbers of endangered species is not from international trade but from activities such as the clearance of land for agriculture.

Each country that ratified CITES pledged to enforce its laws relating to international trade in endangered plant and animal species. The guidelines used for considering a plant or animal endangered were (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, sporting, scientific, or educational purposes, (3) disease or predation, (4) inadequacy of existing regulatory mechanisms, or (5) other natural or human factors affecting its continued existence.

Each plant or animal protected by CITES is listed in one of three appendixes:

> Appendix I organisms are considered to be at serious risk as a result of international trade, thus trade in these organisms between signatory countries is banned unless an export permit is obtained from the country of origin, and an import permit from the country of destination, a process that is often time consuming and expensive. On the other hand, plants listed in Appendix I that are grown from seed in registered nurseries need only an export permit.

> Appendix II organisms may be threatened by excessive amounts of trade, but trade is permitted with appropriate licenses, various kinds of monitoring, and certain controls.

Appendix III is used by countries that want to control trade in certain organisms not currently listed in either of the other appendixes.

All cycads are listed in either Appendix I or II of CITES. All species of *Ceratozamia, Chigua, Encephalartos* as well as *Cycas beddomei, Microcycas calocoma,* and *Stangeria eriopus* are listed in Appendix I. All other cycads are listed in Appendix II.

The removal of a plant listed in CITES from countries that are not members of CITES still requires a written permit in lieu of CITES certification. Without a permit, no endangered species will be granted entry into the country of destination. CITES enforcement was slow to take effect, but it has proved to be the single most effective tool for the protection of endangered organisms. Protection of endangered species from wholesale destruction by commercial operators is now almost assured. As with most laws, CITES is not perfect. It has sometimes created a tangle of red tape, making it nearly impossible for the legal exchange of small amounts of propagation material between botanical gardens, researchers, and collectors. In some instances, rigid enforcement of CITES regulations is assisting, rather than preventing, extinction of species threatened by habitat destruction. A good illustration of this problem is the Colombian genus *Chigua.* This genus will have its entire known habitat submerged by the completion of a dam, but collection permits and CITES export permits are virtually impossible to obtain.

One of the major problems encountered in the application of CITES regulations to plants is that CITES was originally written for the protection of animals. If a specimen of an animal is collected for taxonomic research, for example, it means the death of that individual animal. On the other hand, the collection of leaf and cone samples from a cycad for research does not mean death of the individual plant. Even so, CITES documentation must be obtained to transport these scientific specimens legally because they are from an endangered species. Clearly, there is a need to amend CITES regulations to make them more botanically friendly.

The Future for Cycads

Although the future does not look bright for many of the world's cycads, this should not deter us from working to ensure their survival. Education of the public regarding the value of cycads, both historically and commercially, must be encouraged. Making the cycads and their problems better known to the horticultural community is a positive step in the fight for their protection, and a goal of *The Cycads.*

CHAPTER SEVEN

Cycads in Human Activities

In addition to their use in gardens and in cultivation in general, cycads are known to have been used by humans for almost 7000 years. Though they have not loomed large economically, they have been used as food, for ornament and decoration, as medicine, and for a variety of other uses.

Food

J. M. Beaton (1977) reported the earliest known use of cycads, for food. In some Australian Aboriginal caves he had found the charred remains of cycad seeds. When these remains were carbon dated, they were found to date back to approximately 6000–7000 B.P. Australian Aborigines still use cycad seed as a food source. The extracted starch is formed into thin loaves, then baked in the hot ashes of a fire.

The use of cycad starch for food during prehistoric times has been documented from several countries. In the United States, the Caloosa, Seminole, and Tequesta Indians of Florida used *Zamia integrifolia,* known to them as *coonti,* to make a pudding that was said to be a basic ingredient of almost every meal. The Seminole called this *Zamia* pudding *sofkee* and often made a stew from it by the addition of wild game and vegetables.

In the Dominican Republic, the native *Zamia pumila* is known commonly by the name *guayiga.* The local Indians have used it as a food item for many years. The starchy flour produced from the tubers is made into biscuits, rolls called *cholas,* and other specialties called *hojaldres* and *tortillitas.*

In Kenya, two common food items known as *ugali* (porridge) and *chapati* are generally prepared from wheat or corn flour. A tribe known as the Wasanya is unique in the area because they prepare these two foods using cycad flour made from the seeds of *Encephalartos hildebrandtii.* It is said that the cycad flour stores well and can be kept indefinitely. *Ugali* is also made on the islands of Zanzibar and Pemba from starch extracted from the seeds and central portion of the stems (starch from the stem is called *mgwede*) of *E. hildebrandtii.*

In the Ryukyu Islands, Japan, starch removed from the seeds and stems of *Cycas revoluta* has been used as a famine food for many years. It is generally made into a paste called *miso. Miso* usually originates from soybeans and is only made using cycad starch after crops have been destroyed by a hurricane. When soybean *miso* is in short supply, it is often extended by the addition of cycad starch. It has been reported that 100 kg (220 pounds) of seed kernels will produce 27 kg (60 pounds) of pure starch.

On New Guinea, processed cycad starch from a species of *Cycas* is used to make a kind of cake or bread. The starch is mixed with shredded coconut, formed into cakes, wrapped in banana leaves, and cooked on hot stones. Additional hot stones are piled on top and covered with banana leaves to steam the cakes. The cakes may be eaten hot or cold.

On many of the islands of the South Pacific and Indian Ocean, cycad starch is still occasionally used as a food item. These islands include New Caledonia, the Philippines, Fiji, the Nicobar Islands, and Sri Lanka (Ceylon). Cycad seeds, after being leached in seawater, are sliced and steamed, mixed with sugar and grated coconut, and eaten as a delicacy on the Moluccas. On Guam and Rota in the Mariana Islands, the Chamorro Indians have traditionally used *Cycas micronesica* as a source of food and medicine. Although the local population was warned of the possible hazards involved with eating starch derived from cycads, its use persists.

Other countries where cycad starch is occasionally used are Indonesia, Thailand, Myanmar (Burma), India, Mexico, Belize, Guatemala, Honduras, Venezuela, Colombia, Ecuador, and Peru.

Commercial Starch Production

At one time, the commercial extraction of starch from cycad stems was common in the United States (Florida), the Dominican Republic, Australia, and Japan. I am not aware of any existing commercial enterprises for removing starch from cycad stems or seeds.

The Indian tribes of Florida, especially the Seminole, had used *Zamia integrifolia* for hundreds of years as a source of edible starch. This cycad was so abundant throughout Florida and so rich in starch (almost 50%) that some early settlers set up mills to extract it commercially. Historical accounts state that the first mill was opened in 1845, with numerous others started in subsequent years. Most of the commercial starch production in Florida was located along the Miami River and in adjacent coastal areas. The extraction was based on the procedures used by the local Seminole Indians. It was a rather crude process, which consisted of grinding the stems, sifting the ground material, and repeatedly soaking and washing the sediment, which was almost pure starch. The starch was dried, packed in barrels, and shipped to markets in the northeastern states. The cycad starch produced in Florida was sold as "arrowroot" flour. The product was also used occasionally as laundry starch.

From 1845 to 1920, numerous mills were producing cycad starch in southern Florida. Records indicate that a mill owned by John White manufactured 136,000 kg (300,000 pounds) of cycad starch in 1850. In the early 1900s, one mill was reported to have produced as much as 11,000 kg (24,000 pounds) of cycad starch per week! The years of peak production of cycad starch in Florida were 1845 till about 1915. The last mill closed in 1920. Years of exploitation of the *Zamia* populations in Florida must have reduced the number of plants by millions. The mills, coupled with a growing human population that resulted in land clearance, draining of swamps, and urbanization, led to a dramatic reduction in the populations of *Z. integrifolia* throughout Florida. The dwindling *Zamia* populations eventually led to the closing of the mills.

During the time the Florida mills were producing cycad starch, similar mills were established in the Dominican Republic. The large populations of *Zamia pumila* there provided sufficient raw material for starch production. The output of these mills was evidently sold in the West Indies. It is not known exactly when the mills in the Dominican Republic closed, but it is believed to have been in the mid-1920s.

In 1921 a company was formed in New South Wales, Australia, for the extraction of cycad starch from the locally abundant *Macrozamia communis*. Starch was removed from the central portion, or pith, of the stem. The pith was ground in water and the resultant mixture strained through a silk sieve to catch the fibrous material, allowing the starch to pass through. Finally, the starch was purified by leaching in water for a period of time, rinsing, then drying into a fine white powder. The resultant starch was of high quality and was said to perform better than starch produced from rice or corn. Besides being used for food, the starch was used for laundry starch and the production of adhesive paste, alcohol, and glucose. Although cycad starch extraction in Australia thrived for a number of years, it was eventually discontinued, supposedly because of technical difficulties.

Beverages

Alcoholic beverages have been produced on a limited basis from the fermentation of cycad starch. In the Ryukyu Islands, Japan, starch from the seed and stem pith of *Cycas revoluta* was used in the manufacture of a drink similar to sake. The resultant liquor is always slightly poisonous, and rarely a particularly toxic batch has been known to kill all who consumed it. Some tribes in Africa have been reported to prepare a beerlike drink from the stem pith of *Encephalartos*. In Sonora, Mexico, starch from the stems of *Dioon sonorense* was used in the production of an alcoholic beverage similar to tequila. This practice died out when the dioons became too rare to collect commercially.

Poisoning of Humans

It is now widely known that all cycads contain toxins poisonous enough to cause serious illness, even death, if consumed in sufficient quantity. Research has yet to identify all the toxic substances contained in cycad tissue. The two main toxic compounds that have been identified are cycasin and macrozamin. When ingested in sufficient quantities, cycasin and macrozamin are extremely poisonous to humans and other animals. These toxins have been shown to cause liver damage and cancer. Cycasin and macrozamin are also suspected of causing neurological disorders when ingested in small amounts over long periods of time. The inhabitants of Guam and the Ryukyu Islands exhibit an unusually high incidence of amyotrophic lateral sclerosis and parkinsonian dementia, which have generally been blamed on long-term consumption of cycad starch.

The history of the Southern Hemisphere, particularly Australia, includes numerous incidents of cycad poisoning. As early as 1697, the Dutch explorer Willem de Vlamingh and his men were poisoned in the vicinity of what is now Perth, Western Australia, by eating seeds of *Macrozamia riedlei*. In 1770 the explorer James Cook, his men, and their pigs were poisoned in Australia by eating seeds of *Cycas media* while exploring the area of the Endeavour River. In 1901, during the Boer War in South Africa, Jan Smuts and his commandos were poisoned by eating seeds of *Encephalartos longifolius* (incorrectly identified at the time as *E. altensteinii*). Many other incidents of cycad poisoning have been chronicled.

The worldwide use of cycad starch as an item of food has no doubt been responsible for numerous incidents of poisoning. It is extremely interesting to consider how various primitive cultures have all been able to develop ways of eliminating the toxins from cycad starch. It is especially interesting to contemplate, since all have developed more or less the same process. One wonders how many people died before the procedure for removing the toxins was perfected.

In Kenya, the Wasanya tribe cut the seed kernel of *Encephalartos hildebrandtii* into thin slices that are then dried in the sun 1–2 days before being ground into a fine flour. The flour is placed in a pail of water, the water changed daily for 8 days, and the resultant course flour sun dried, then ground into a fine powder, which is ready for consumption. If animals drink the water used to remove the toxins, they are said to develop bloody diarrhea and die within a few days. Humans eating improperly prepared starch exhibit gastrointestinal irritation, vomiting, diarrhea, apathy, and headache. Children are said to display symptoms of jaundice and die in 2–6 days.

On the island of Zanzibar, fully ripened seeds of *Encephalartos hildebrandtii* are cracked open and the flesh sun dried about 4 days or until it becomes as hard as stone. The seeds are then fermented in a metal pail with banana leaves about a week. After fermentation, the seeds are cleaned of mold, soaked in water, then ground into a paste. The paste is sun dried and ground into a fine powder, which is ready to use for food.

In Japan, especially in the Ryukyu Islands where *Cycas revoluta* is very common, the natives have had to rely heavily on the use of cycad starch in their diet. On the island of Amami, the natives dislike cycad starch and refer to the island as the cycad hell. Starch is removed from both seeds and stems. Stems are detoxified by removing the central pith, cutting it into small pieces, then storing it under a straw mat for several days until it becomes covered with black fungus. The pieces are then ground, washed in water, and the residue dried in the sun. Seeds are crushed, sun dried, ground in a stone mill, then strained through cheesecloth. The resultant powder is soaked in water overnight, then drained. The residue is washed several times, then boiled. If these methods are not adhered to, the resulting starch may still be contaminated with toxins. Symptoms of cycad poisoning are heavy perspiration, vomiting, finally the loss of consciousness.

On New Guinea, the natives split the seeds of a *Cycas* in half after removing the outer fleshy covering, the sarcotesta. The kernels are then soaked in water 2–3 weeks. The natives insist that the water must not be changed and that the seeds must "stink finish" to remove all poison. The kernels are then mashed, washed, and dried.

On Guam, seed kernels of *Cycas micronesica* are removed and soaked repeatedly in changes of fresh water. After about a week the macerated kernels are ground in stone cavities, then formed into loaves and baked. It is said that the Chamorro Indians first learned how to process and detoxify the seed and stem of *C. micronesica* from the Spanish around 1800, but this is doubtful in view of the history of cycad use on other islands of the South Pacific.

Poisoning of Livestock

Livestock poisoning through ingestion of cycad leaves and seed has been reported from numerous countries. The major areas of concern include Australia, New Guinea, Mexico, Bahamas, Puerto Rico, and the Dominican Republic. Cattle and sheep are most commonly affected, but goats, horses, and pigs are also at risk. It seems that only introduced livestock are usually affected. Animals native to the areas of the cycads either do not eat them or are not adversely affected by their consumption. It has been reported that crows and ravens eat the seed of *Zamia* without ill effects but that domestic turkeys are killed. Livestock poisoning by cycads has been a major problem in Australia for many years. Often, cycads are the only green plants available for grazing, especially during the dry season. Their green leaves are too tempting for livestock to ignore. Experiments have shown that green leaves and young shoots are more toxic than dry leaves.

The initial signs of cycad poisoning in livestock are partial paralysis or weakness of the hindquarters. As the condition progresses, the animals find it increasingly difficult to walk and finally are unable to stand upright. When they are no longer able to move about, they die of starvation or thirst. In Australia the condition is referred to as zamia staggers and is also known as rickets or wobbles. Cycad poisoning is cumulative, and livestock that continue to feed on cycads will become progressively weaker and eventually die from its effects. Cycad poisoning is apparently incurable. Once its effects become apparent, the condition is believed to be irreversible. Symptoms will remain throughout the life of the animal even if it is moved away from the source of the toxic food.

In the Dominican Republic, the condition of cycad poisoning in livestock is called *derrienque* and is generally restricted to cattle. In 1964 the government of the Dominican Republic reported that there were approximately 40,000 cattle in the country. Of these, approximately 500 are affected yearly by cycad poisoning. It was stated that those affected were only the adults and that they did not die but only developed paralysis in the hindquarters. The cycad responsible for these poisoning incidents is *Zamia pumila*. In some areas of the country, this species is very common in pastureland and almost impossible to eradicate. In areas where control of the zamias was achieved there were no incidents of *derrienque*.

For many years, losses of livestock from cycad poisoning has caused major economic losses to ranchers. The Australian government addressed this problem by declaring all cycads noxious weeds. For a number of years the Australian government produced pamphlets giving directions for the eradication of cycads. Notching the stem and introducing arsenic killed arborescent species such as *Macrozamia moorei*. Subterranean species were killed by splitting the crown with an ax, then pouring kerosene into the wound. Hundreds of thousands of cycads were destroyed in this manner. More recently, ranchers have found it less time consuming and more cost effective to fence off large cycad colonies, thereby keeping livestock from coming into contact with the cycads, indirectly aiding in preservation of the cycads.

Ornament

The most prominent use of cycads for ornament is horticultural, for enjoyment in gardens or in containers. There are, however, a number of other, less known uses of cycads as well.

Since before World War II the inhabitants of the Ryukyu Islands, Japan, have exported large numbers of dried leaves of *Cycas revoluta*. Currently, this export amounts to about 60,000 leaves annually. In the early days, most of this production went to Java where it was used in the production of funeral wreaths, but now the majority of the export goes to the United States, Germany, and Switzerland. The dried leaves are usually painted and used in the manufacture of floral decorations and wreaths.

In Asia, especially Japan, *Cycas revoluta* is often grown as bonsai, a dwarfed pot plant. The art of bonsai is also common in China and Thailand. *Cycas revoluta* has also been a subject in large, painted antique Japanese screens used to separate living areas (Plate 29), on cloisonné plates (Plate 30), and in woodblock prints (Plate 31).

In the South Pacific, the native *Cycas* species are not uncommonly planted as grave markers. The cycads are transplanted for this use by chopping off a stem, which is then planted. Roots soon form and the plant grows.

In the United States, fresh leaves of *Cycas revoluta* (and other species of *Cycas* from Asia and the South Pacific that are usually misidentified as *C. circinalis* but are, in fact, a variety of different species) have gained popularity for use in flower arrangements. Most of the cycads that provide these leaves are grown in Hawaii or Florida and shipped to cities across the country.

Cycad leaves may be used in various countries for decoration during religious holidays such as Palm Sunday. In 1987 I observed *Ceratozamia* leaves used to decorate a shrine in Hidalgo, Mexico (Plate 32). In Chiapas, not far from the Mal Paso Dam in adjoining Oaxaca, I found large specimens of *Ceratozamia* that had finally died from the continual collection of their leaves over a long period of time. Also in Chiapas, leaves of *Dioon merolae* are collected in April to be used as alter decorations during the festival of Santa Cruz on May 3. In Honduras, leaves of *D. mejiae* are used to decorate altars and to construct funeral wreaths.

A devastating use of *Dioon* in Mexico is the practice of chopping off the top section of the stem with a full head of leaves. The leaf tips are then bent down and fastened to the stem in order to produce a crownlike arrangement. The stem is placed in a dish of water and used as a table decoration. The plant from which the crown was cut will eventually produce a new bud or buds but this requires 10–15 years or more. During this regrowth period, these plants are incapable of producing cones and seeds.

In South Africa, the use of leaves of *Encephalartos lanatus* for altar decorations has been documented in the area of Middelburg, Mpumalanga. In the Eastern Cape, it is not uncommon to find *Encephalartos* plants used as markers on graves, and many cemeteries have numerous cycads growing on old gravesites.

Botanical journals such as *Curtis's Botanical Magazine* and *L'Illustration Horticole* contained many fine hand-colored illustrations of new plant species, especially those issues produced in the nineteenth and early twentieth centuries. Unfortunately for the preservation of runs of these journals, prints detached from them are framed and used for wall decorations.

A better way to collect fine cycad art is to collect original paintings or books that feature the work of artists who use cycads as subjects. One of the finest cycad artists is Douglas Goode of South Africa. He is well known in the world of science as an expert illustrator of plants, insects, and other animals but is most famous for his book, *Cycads of Africa,* in which he painted all the known species. Goode began work on his book in the early 1960s and it was finally completed and published in 1989. His book not only provided his beautiful paintings but a wealth of information from firsthand observation of plants in the wild.

Another fine cycad artist is Priscilla Fawcett. She worked for a number of years at the Royal Botanic Gardens, Kew, England, before moving to the United States, where she continued her artwork at the Fairchild Tropical Garden, Miami, Florida. While at Fairchild she produced two beautiful paintings, one of cycad cones and another depicting the life history of *Zamia integrifolia* (as *Z. pumila*). Reproductions of her cycad artwork are also to be found in *The Biology of the Cycads,* co-authored by her husband, Knut J. Norstog, and Trevor J. Nicholls (1997).

In the graphic arts, occasional use has been made of cycads on postage stamps (Plate 33). The Ryukyu Islands, now part of Japan, at one time issued postage stamps. In 1948 the red 5-sen and green 20-sen stamps depicted *Cycas revoluta* in identical designs, then in 1968 an unemployment stamp was issued showing a multistemmed specimen. In 1970 a 3-cent stamp was issued for Cultural Properties Protection Week picturing the great cycad of Une, which was claimed to be more than 6 m (20 ft) tall and have more than 200 branches, and estimated to be more than 250 years old. A multicolored tuberculosis seal was printed in 1961–1962, also showing *C. revoluta.* In 1967 a postcard was issued depicting a preying mantis and an insect cage that children weave from a single cycad leaf and that is used to house crickets, locusts, and grasshoppers.

Encephalartos ferox in cone was used on a 1977 stamp from Mozambique, then in 1993 two more stamps were issued, one with *Cycas circinalis* (?) and the other with *E. ferox* again. Transkei issued four stamps in 1980 depicting *E. altensteinii, E. friderici-guilielmi, E. princeps,* and *E. villosus.* Transkei followed this four-stamp series with another in 1990 featuring fossil cycads. Also in 1990, England produced a stylized cycad stamp commemorating the sesquicentennial of the Royal Botanic Gardens, Kew. In 1993 Lesotho issued four dinosaur stamps, one with two cycads on it. In 1996 the United States issued a sheet of stamps, the "World of Dinosaurs," the upper half displaying three cycads. In the same year the United Nations issued a set of four stamps on endangered species, one of which featured *E. horridus.* Also, China issued a set of four cycad stamps to celebrate Cycad 96, the Fourth International Conference on Cycad Biology, held in Panzhihua, Sichuan. These stamps depict *C. multipinnata, C. panzhihuaensis, C. pectinata,* and *C. revoluta.* Zimbabwe produced a set of five stamps in 1997 to commemorate the tenth meeting of CITES, one of which has an *Encephalartos,* probably *E. manikensis,* featuring a plant with a female cone and an inset of a male cone.

The Fourth South African Infantry Regiment badge has a four-color cloisonné insignia of a cycad (Plate 34). The regiment has its headquarters near Middelburg, Mpumalanga, and it is said that both *Encephalartos lanatus* and *E. middelburgensis* grow on the base. South Africa issued a 50-rand note in 1984 with an engraving of *E. transvenosus* on its reverse side (Plate 35).

The coat of arms of Vanuatu, an island country in the South Pacific, depicts a person holding a spear, framed by boar tusks, with two crossed *Cycas* leaves behind him. This crest is used on many of the coins and some of the notes of Vanuatu (Plate 35).

A bronze box in my collection is decorated with several medallions depicting plants (Plate 36). One of these is unmistakably *Cycas revoluta* with a female cone. The box was produced about 1920 by Tiffany Studios, New York City.

Allen Adams of Los Angeles, California, has produced ceramic impressions of cycad leaves. These impressions are glazed, fired, and beautifully framed. More recently, Linda Smith of Rancho Santa Fe, California, has made jewelry from dry cycad seeds and silver wire (Plate 37). These innovative pieces include bracelets, necklaces, and key rings.

Medicine

In Asia, the seeds of *Cycas revoluta* are commonly used for the treatment of ailments such as diarrhea, tuberculosis, neuralgia, and to "strengthen the body." These recommendations have been found in both Japanese and Chinese folk medicine.

In Indonesia, cycad starch is used as a remedy for various skin lesions. The sodden mass of starch is placed on a leaf, which is then strapped into position over the lesion and left in place until the lesion has healed over.

In India, male cones of *Cycas beddomei* are known as *per ita* and are supposed to have a cooling effect when prepared in a dried and sugared form. The male cones are also used to treat rheumatism and muscular pains. The pith of the stem is said to be used to treat stomach pains.

Other Uses

In the Ryukyu Islands, Japan, doll-like toys are made from the dried seeds of *Cycas revoluta*. These are painted or lacquered and used by the local children. Cycad stems are also carved into ornaments for export. In India, snuffboxes have been constructed from the sclerotesta of *C. circinalis*. In Australia, the large seeds of *Lepidozamia peroffskyana* have been cut in half, hinged, and used as matchboxes. In Mexico, whistles and toys have been made from the large seeds of *Dioon spinulosum*. In the early history of Florida, dried stems of *Zamia integrifolia* were carved into pipe bowls.

CHAPTER EIGHT

The Cycads

The accepted scientific name is followed by its author and the year of naming, constituting a reference to the Bibliography. Any synonyms are listed, followed by an explanation of the accepted name. For genera, the number of species, the name of the type species, and the chromosome number are given, with a mention of the sections if such subdivision of the genus is recognized, and for each genus the name of the family to which it belongs is given. Chromosome numbers are helpful in understanding relationships between genera, and in *Zamia,* where there is variation in chromosome number between species (the number given for each species when known), even within a species, they are useful also in understanding relationships within the genus. Following this are descriptions of the stems, leaves, female cones, male cones, habitats, and distribution, ending with remarks on various aspects of each genus and species, such as history, distinctive features, cultivation, and conservation status.

The descriptions have measurements given in metric units followed by equivalents, for measurements longer than 5 mm (0.2 in), in inches, feet, or miles, or degrees Fahrenheit for temperatures given in centigrade. The information in the descriptions is taken from several sources, including the original descriptions of the plants, other accounts such as monographs, herbarium specimens, and living plants, both wild and in cultivation. The descriptions attempt to recognize the variability within a genus or species, usually by giving a range of measurements. Descriptions may include a single measurement, usually preceded by the word about, and in these cases the measurement often was obtained from the original description where only a single measurement was available and no other measurements were found or could be made. Occasionally, individual plants will be found that have measurements falling outside the ranges given here, and that is often true for cultivated plants where the ready availability of water and fertilizer allow a plant to exceed the dimensions of those growing under normal conditions in their original habitat.

Bowenia W. J. Hooker ex J. D. Hooker 1863

Bowenia is named in honor of Sir George F. Bowen (1821–1899), the first governor of Queensland, Australia, serving at the time the genus was described. Two species (type, *B. spectabilis*). Chromosome number $2n = 18$. *Bowenia* together with *Stangeria* constitute the family Stangeriaceae.

Stems subterranean, tuberous, either turnip or potato shaped, from which arise stems or necks, the apexes of which produce cataphylls, then either leaves or cones.

Leaves most distinctive, bipinnate, no other cycads except *Cycas multipinnata* and *C. debaoensis* having bipinnate leaves. In habitat, bowenias could be mistaken for large maidenhair ferns (*Adiantum*) with glossy leaflets.

Female cones about fist size, globose, solitary to each bud, a single plant may have several but only one produced at each growing point. Pollination must be by insects as both female and male cones generally produced under leaf litter, making wind pollination nearly impossible. Ripe seed white to blue, turning brown, dispersal probably by rodents or other mammals.

Male cones solitary at each growing point or bud, at first erect, then leaning, cylindrical, about 7.5 cm (3 in) long and 2.5 cm (1 in) in diameter, more or less white or cream with the portions exposed to light turning green, short-lived and rotting away soon after the pollen is shed.

HABITAT: Rain forest or along the margins of rain forest from sea level to about 600 m (2000 ft).

DISTRIBUTION: Australia, Queensland, mainly low coastal areas but with some populations extending onto the Atherton Tableland.

Bowenia, because of its bipinnate leaves, sometimes tripinnate in *B. serrulata,* is remarkable among the cycads. This feature easily separates it from all other Australian genera. Immature or even mature specimens of *Bowenia* could easily be mistaken for large maidenhair ferns (*Adiantum*). The similarity with ferns, combined with the fact that its rain forest habitat contains abundant fern species, makes such a mistake understandable. Both species of *Bowenia* are listed in Appendix II of CITES.

Bowenia serrulata (W. Bull) Chamberlain 1912

PLATES 38, 39

Bowenia spectabilis var. *serrulata* W. Bull 1878, *B. spectabilis* [var.] *serrulata* T. Moore 1878

Bowenia spectabilis var. *serrata* F. M. Bailey 1883

Bowenia serrulata, the epithet the Latin diminutive for serrate and referring to the margins of the leaflets, is called the Byfield fern. STEMS subterranean, tuberous, smooth, naked, subspherical, 20–50 cm (8–20 in) or more in diameter, with 5–20 short, slender, leaf- and cone-bearing branches. LEAVES usually 5–30, one or more on each branch, bipinnate, rarely tripinnate, erect, 1–2 m (3.3–6.6 ft) tall, and glossy dark green. Petiole 1–2 m (3.3–6.6 ft) long, 8–12 mm (0.3–0.5 in) in diameter, the base and cataphylls persistently tomentose. Rachis divided into three to five pairs of branches, each bearing 6–16 pairs of leaflets. Leaflets 5–10 cm (2–3.9 in) long, 1.5–4 cm (0.6–1.6 in) wide, sharply serrate with rather pungent teeth 1–3 mm long. FEMALE CONES solitary, erect, subglobose, 8–11 cm (3.2–4.3 in) long, 11–13 cm (4.3–5.1 in) in diameter, dark green, the surface with a sparse brownish tomentum, average cones with 25–35 seeds. Peduncle 25–45 mm (1–1.8 in) long, about 12 mm (0.5 in) in diameter, the cone often appearing sessile. Sporophyll face 18–25 mm (0.7–1 in) high, 3–4 cm (1.2–1.6 in) wide, the facets more or less distinct with the terminal facet somewhat sunken. Sarcotesta somewhat purple when ripe. Sclerotesta ovoid to irregularly globose, 28–36 mm (1.1–1.4 in) long, 22–26 mm (0.9–1 in) in diameter, light tan, smooth. MALE CONES solitary on each branch of the tuber but a single plant capable of producing 10–15 or more branches, cone erect, more or less cylindrical, 7.5–11.5 cm (3–4.5 in) long, 3–4.5 cm (1.2–1.8 in) in diameter, dark green until pollen shedding, when the light cream-colored interior becomes visible. Peduncle 22–45 mm (0.9–1.8 in) long, 15–20 mm (0.6–0.8 in) in diameter. Sporophyll face with a prominent central depression, face of median sporophyll 3–5 mm (to 0.2 in) high, 8–10 mm (0.3–0.4 in) wide. HABITAT: Dense, wet, coastal sclerophyll forest only slightly above sea level. Rainfall averages 925 mm (36 in) annually. Daytime temperatures average 32°C (90°F) during the hottest month, 10°C (50°F) during the coldest, with the lowest recorded 0°C (32°F). DISTRIBUTION: Australia, central coastal Queensland in the vicinity of Rockhampton, north to Byfield and Yeppoon.

Bowenia serrulata is not frequently encountered in botanical gardens or private collections. This lack of material is not the result of rarity, as the species is quite common within its range, but rather the difficulty of growing it in pots. Bowenias do not do well in a heavy growing medium. Charles J. Chamberlain (1919), in *The Living Cycads,* related a conversation in which he learned of *B. serrulata* that had not produced a leaf in 20 years growing in a pathway. Once the house and path were abandoned, a fine display of leaves soon emerged. This illustrates the tenacity of these plants' hold onto life under adverse conditions, in contrast to the difficulty experienced in cultivating them.

Bowenia serrulata may be easily separated from *B. spectabilis* by noting the presence of serrations or teeth along the margins of the leaflets. In *B. spectabilis* the margins are entire, though in some cases leaflets may be lacerate. The leaves of *B. serrulata* are sometimes used in flower arrangements, and they were known for many years by the name of Byfield Fern. The leaves of *B. serrulata* give the appearance of ferns but because of their thicker texture they remain in good condition for many days, even without water. It has been reported that leaves of *B. serrulata* were once commonly used to decorate the windows of butcher shops.

There is a population of *Bowenia* with serrate leaflet margins in the Tinaroo Dam area on the Atherton Tableland in central Queensland, Australia. Its distribution has not been reported as overlapping with that of *B. spectabilis,* though that cycad occurs in close proximity. The Tinaroo plant differs from *B. serrulata* of the Byfield area by its bronze emergent leaves, spindle-shaped rather than round tuber, and narrower, more finely serrate leaflets (Plates 40, 41). Additionally, *B. serrulata* occurs just slightly above sea level in coastal areas whereas the Tinaroo form is found at an elevation of 420–700 m (1400–2300 ft) on the drier Atherton Tableland. Another difference worth noting is that the leaf-eating beetle *Lilioceris nigripes* will feed on leaves of the Tinaroo *Bowenia* but does not feed on leaves of *B. serrulata* or *B. spectabilis.*

When grown well, *Bowenia serrulata* is a handsome and interesting cycad. Some growers have been able to produce fine specimens starting only with a branch called a neck, that portion producing the cones and leaves that arises from the tuber. These branches, after rooting, develop into a normal plant with its typically large, rounded tuber. By far the easiest way to start *B. serrulata* is from seed. Seed germinates rapidly, and a seedling with two or three leaves can be expected within the first year. If given a light, well-drained, aerated soil mix and a deep pot, seedling growth is quite good. Root development is rapid, and the large, fleshy roots soon fill the pot. As the seedling grows, the uppermost portion of the root, just below the bud, swells and develops into a tuberous stem. As true of most cycads, bowenias prefer open, well-drained soil, and plenty of fertilizer. Bowenias are basically understory plants and the best light condition for them is about 50% shade. Bowenias are somewhat cold tolerant, and I have not observed defoliation of my garden plants when they were subjected to several degrees of frost.

Bowenia serrulata does not appear to be threatened. Seed production is adequate and regeneration good. As with some other cycads, seed production can be somewhat cyclic, with 2–3 years of few female cones, then a year in which coning is profuse. It has been noted that heavy seed production usually follows a fire.

Bowenia spectabilis W. J. Hooker ex J. D. Hooker 1863

PLATES 42–45

Bowenia spectabilis, the epithet derived from *spectans,* Latin and meaning to be seen and esteemed, is called the zamia fern. **Stems** subterranean, tuberous, elongate, naked, the surface often warty, irregularly spindle shaped rather than round, in mature plants about 30 cm (12 in) long and 12.5 cm (5 in) in diameter, the tuber crown producing one to five short, slender, leaf- and cone-bearing branches. Cataphylls and petiole bases persistently tomentose, the cataphylls short, flat, ovate triangular, scattered among the leaf bases. **Leaves** one to several on

Bowenia spectabilis

each branch, bipinnate, upright and 1–2 m (3.3–6.6 ft) tall then horizontally spreading, the horizontal spread 1–2 m (3.3–6.6 ft) long and 1–1.5 m (3.3–4.9 ft) wide, glossy dark green, emergent leaves either bright green or brownish green, and lightly tomentose. Petiole terete, 0.5–1 m (1.6–3.3 ft) long, 3–8 mm (to 0.3 in) in diameter, usually unarmed, infrequently with one or more scattered blunt spines. Rachis terete, with 4–10 secondary branches, each bearing 9–15 pairs of leaflets. Leaflets 10–15 cm (4–6 in) long, 1.5–5 cm (0.6–2 in) wide, thin textured, falcate lanceolate, margin entire though leaflets sometimes lacerate. Female cones solitary, emerging at ground level or slightly below, ovoid or globular, apex rounded, 8–10 cm (3.2–4 in) long, 6.5–10 cm (2.6–4 in) in diameter, size variable according to size of the plant, with 22–90 seeds, cones usually ripening April–June. Peduncle short, cone appearing sessile. Sporophylls with expanded ends hexagonal with a terminal central depression, facets not distinct, exterior dark green but the whitish interior showing between the sporophylls. Sporophyll face hexagonal, 15–19 mm (0.6–0.7 in) high, 30–55 mm (1.2–2.2 in) wide. Sarcotesta at first white, brown to purplish when ripe. Sclerotesta globose to ovoid, 2–3 cm (0.8–1.2 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, light tan, smooth. Male cones solitary on each branch from the tuber, but a single plant capable of having 5–10 or more branches, cones more or less cylindrical, 7.5–9.5 cm (3–3.7 in) long, 2–2.5 cm (0.8–1 in) in diameter, green but when elongated for pollen shedding the prominent white to cream interior exposed, the cataphylls about 35 mm (1.4 in) long and 4 mm wide at their base, somewhat folded with a thickened midsection, covered with dark brown tomentum that is much longer than that on the cone or peduncle. Peduncle 3–4 cm (1.2–1.6 in) long, 1–1.2 cm (0.4–0.5 in) in diameter, densely covered with dark brown tomentum. Median sporophylls 6–7 mm (0.2–0.3 in) long. Sporophyll face broadly wedge shaped, 5 mm (0.2 in) high, 8–9 mm (0.3–0.4 in) wide, with the terminal facet more or less truncate, subhexagonal with a central depression, lightly dark brown tomentose. Sporangia in two closely spaced patches. Habitat: Open areas in rain forest or bordering rain forest from sea level to about 700 m (2300 ft). Rainfall ranges 1500–2500 mm (59–98 in) annually, falling mainly in summer. Summer high temperatures reach 30°C (86°F), and winter lows average 17°C (63°F) with the lowest recorded temperature slightly below 0°C (32°F). Distribution: Australia, Queensland, northeastern coast and ranges from Rockingham Bay in the south to Cooktown in the north. A 1953 report on a collection from Leo Creek in the McIlwraith Range, northeast of Coen on the Cape York Peninsula, may refer to *Bowenia spectabilis.* A second report of a *Bowenia* observed in the Iron Range in northern Cape York Peninsula may also refer to this species.

Bowenia spectabilis is the best represented species of the genus in botanical gardens and private collections. In many cases it has proven to be a difficult plant in cultivation. One of the problems may be rough handling of the collected tubers, which tend to rot slowly away when damaged. I encountered this problem at one time with some imported plants, and in spite of the liberal use of bottom heat and careful monitoring of moisture, most of the plants died. The remaining plants I gave up as lost and buried in the garden. Within a year they produced leaves, and these plants are still growing.

Bowenias may go into a dormant state for long periods of time. This is usually brought about by some negative factor such as lack of proper water, fertilizer, or heat. I remember a small seedling planted in my garden that "died," then reappeared after 4 years when the sprinkler system was renovated and the *Bowenia* began to receive sufficient water. A quote from an article on *B. spectabilis* in the December 1872 issue of the *Botanical Magazine* is of interest:

> The tuberous stem of *Bowenia* has the property of remaining dormant for years, and resisting all excitements to growth. A small cylindrical specimen, about three inches [7.6 cm] by about two-thirds of an inch [1.7 cm] in diameter, received at Kew in the year 1864, and which arrived with a healthy leaf, soon lost it, and remained for four years leafless, making very little root, and developing no bud; it was plunged into strong bottom heat for months; and again kept moderately cool for as long; it was kept dry at one time and copiously watered at another, but all to no purpose; at last it made a push and produced a fine frond, and subsequently a male cone, with considerable rapidity.

Grown from seed, *Bowenia spectabilis* does not seem to present many problems in cultivation. Growth is rather rapid and a respectable specimen can be produced in about 5 years. Plants do well in well-drained soil with plenty of fertilizer during the growing season. Problems can be caused in pots if the soil does not drain well, so a loose, airy mix should be provided. *Bowenia spectabilis* is best suited to tropical and subtropical areas but will also grow reasonably well in temperate climates. In temperate areas some overhead cover is required to keep the leaves in good condition and to protect the plant from frost damage.

There is no doubt that *Bowenia spectabilis* is pollinated by insects. In its habitat the cones emerge from the ground under leaf litter on the forest floor. Female and male cones are generally completely covered, making wind pollination impossible. When searching for seeds it is necessary to reach into the leaf litter at the base of each *Bowenia* leaf until a female cone can be felt and then uncovered. Only about one in 50 plants will be found with seed, so collecting is a long, tedious job.

In its habitat, *Bowenia spectabilis* grows as scattered plants in rain forest or along the margins of rain forest. It does not form dense colonies, as does *B. serrulata.* The conservation status of *B. spectabilis* seems to be secure. The distribution area is extensive, and within it *B. spectabilis* is common though scattered. Lumbering operations in some areas have caused widespread damage to its habitat. Because of the subterranean habit, however, populations survive well in second-growth forest. The adaptability of *B. spectabilis* is noteworthy, and well-grown plants can be found in full sun as well as deep shade. With its extensive range, some of it in large areas of protected rain forest, and ample regeneration, *B. spectabilis* is not considered threatened.

Ceratozamia Brongniart 1846

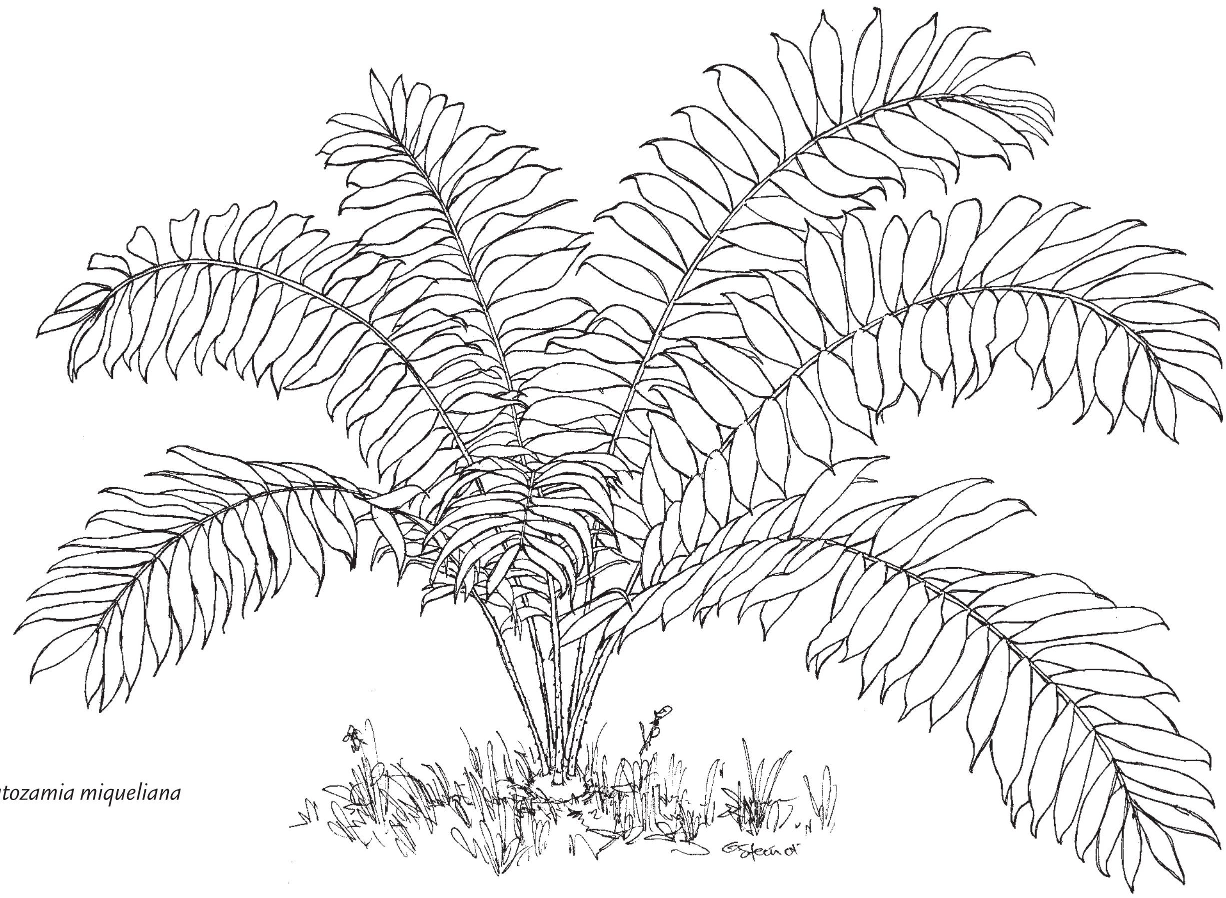
The name *Ceratozamia* is derived from *cerato,* Greek for horned, referring to the two horns on each sporophyll, a characteristic easily separating this genus from all other cycads, and *Zamia.* Eighteen species (type, *C. mexicana*) with the possibility of others as the genus receives additional fieldwork and taxonomic study. Chromosome number $2n = 16$. *Ceratozamia* together with most of the other cycad genera constitute the family Zamiaceae.

Stems in the largest species are generally less than 1 m (3.3 ft) long, very rarely as long as 2 m (6.6 ft). The species producing the largest stems are usually decumbent or pendent and rarely erect in their growth habit. Most species have short cylindrical stems, either upright or leaning. The smaller species usually have subterranean stems with only the crown rising above ground level. *Ceratozamia,* unlike *Zamia,* has a woody stem covered by old leaf bases. This feature can usually be used to separate the two genera in the absence of cones.

Leaves quite variable as to length, width, and the number in a crown. The dwarf species produce one to five leaves whereas the larger species have large crowns of leaves to 3 m (10 ft) long or more and 1 m (3.3 ft) wide. The petioles are usually armed with long and sometimes hooked spines, but some of the dwarf species, *Ceratozamia zaragozae* and *C. kuesteriana,* for example, are completely unarmed. The margins of the leaflets are always entire except in rare cases where leaflets may be lacerate as a result of injury during leaf production. Emergent leaves are normally bright green, but some species have brownish to purple-brown leaves, slowly fading to green as the leaves mature. Some species retain the brownish color on the rachis or underside of the leaflets until the death of the leaf. It has been noted that color dimorphism is exhibited in some populations where individual plants may have either green or brownish emergent leaves.

Species identification of immature plants of *Ceratozamia* is very difficult because seedling leaves and leaflets do not resemble those of the adults in most cases. As the juveniles mature, the leaflets become either narrower or broader until the adult leaflet length and width are achieved. Where twisting of the rachis is a diagnostic feature of the adult plant, in *C. zaragozae,* for example, the seedling or juvenile plants may not exhibit this feature.

Cones separating the genus from all other cycads, each sporophyll of both female and male cones with two

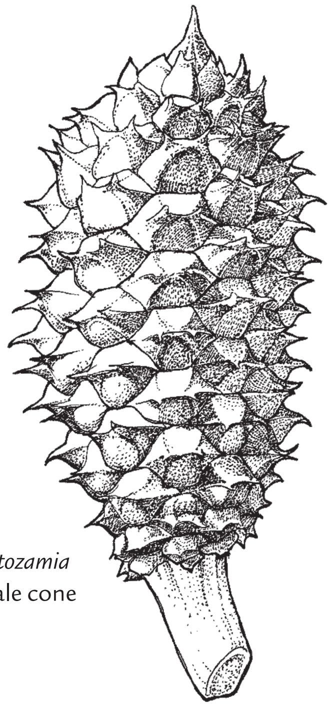


Ceratozamia miqueliana

horns or spines that immediately identify the plant bearing them as a *Ceratozamia.* In the absence of cones, ceratozamias have in many cases been misidentified as zamias. Examination of the stem will then usually separate the two genera, with *Ceratozamia* having persistent leaf bases and a woody stem whereas *Zamia* has a smooth-skinned tuber. All ceratozamias have entire leaflet margins whereas most zamias have marginal teeth. None of the ceratozamias produces seeds with a colorful sarcotesta. This is probably because the seeds are mechanically dispersed as the cones open on the steep banks and cliffs on which the plants are normally found. Birds are the only biological dispersing agent known for *Ceratozamia.*

Habitat: Steep canyons and cliffs, generally in dense shade. Ceratozamias grow in shallow soils composed of a high percentage of humus produced by litter falling from the tree canopy that shades them. Their habitats are usually damp to wet, the moisture coming from streams or heavy fogs and rains from the clouds that build up along the coastal slopes. These areas not only produce the moisture and shade most ceratozamias require but also protect their brittle leaves from wind damage.

The elevational range for species of *Ceratozamia* varies, and they can be found from almost sea level to more than 2500 m (8000 ft). For this reason ceratozamias exhibit a fair amount of cold tolerance and can usually be grown outdoors in areas of light frost, provided they have overhead cover. Those species least able to contend with mild freezes are those with papery leaflets such as *C. euryphyllidia, C. miqueliana,* and *C. whitelockiana,* all plants from low-elevation, wet, tropical habitats. The most common association for *Ceratozamia* is pine-oak woodland.



Ceratozamia
female cone

Distribution: Most species of *Ceratozamia* are from Mexico, with small populations extending into Belize, Guatemala, and Honduras. The distribution in Mexico is loosely on a north-to-southeast arc starting on the Gulf of Mexico in the state of Tamaulipas, following the Sierra Madre Oriental across the Isthmus of Tehuantepec, ending in Honduras. The distribution on the western coast starts in southern Oaxaca, or possibly Guerrero, includes Chiapas, and continues into Guatemala. In almost all cases the distribution pattern follows the coastal mountains, which tend to catch the moisture flowing inland from the Gulf of Mexico or the Pacific Ocean.

Ceratozamia contains an interesting and diverse group of species. They are found in a wide range of habitats, from rain forest, cloud forest, dry pine oak forest, to desert, over a large range of elevations. As would be expected, these varied habitats have produced a number of distinctive leaf forms. Leaflets in *Ceratozamia* range from less than 3 mm wide in *C. zaragozae* to 163 mm (6.4 in) in *C. euryphyllidia.* **Leaves** range in length from 60 cm (2 ft) to 3.6 m (12 ft). **Stems** show similar variation in length, 7.5 cm (3 in) to 2 m (6.6 ft). All species of *Ceratozamia* are listed in Appendix I of CITES.

Ceratozamia alvarezii Pérez-Farrera, Vovides & Iglesias 1999

Ceratozamia alvarezii is named in honor of Miguel Álvarez del Toro (d. 1996), a conservationist instrumental in the establishment of the first biological reserves in Chiapas, Mexico. **Stems** subterranean to shortly arborescent, subglobose to cylindrical, suckering freely from the base, 10–50 cm (4–20 in) long, 8.9–17.5 cm (3.5–6.9 in) in diameter. Cataphylls stipulate, persistently tomentose, 2.1–5 cm (0.8–2 in) long, 1.5–3 cm (0.6–1.2 in) wide. **Leaves** generally 4–18, flat, arching, 0.5–1.1 m (1.6–3.6 ft) long, 31.5–61 cm (12–24 in) wide. Petiole 14–42 cm (5.5–17 in) long, moderately armed with short stout prickles 2–5 mm (to 0.2 in) long, persistently tomentose, sometimes slightly twisted. Leaflets in 24–62 pairs, linear lanceolate, flat, leathery, tomentose when emergent, glabrous with age, dark green above, lighter green below, median leaflets 16–32.5 cm (6.3–13 in) long, 5–9 mm (0.2–0.4 in) wide. **Female cones** solitary, erect, cylindrical to barrel shaped, 14.5–19 cm (5.7–7.5 in) long, 57–10.5 cm (2.2–4.1 in) diameter, olive green. Peduncle erect, 45–65 mm (1.8–2.6 in) long, 18–22 mm (0.7–0.9 in) in diameter, tomentose. Sporophylls shield shaped, arranged spirally but appearing as if in vertical rows, 28–45 mm (1.1–1.8 in) long. Sporophyll face hexagonal, more or less flat, bicornate, 18–20 mm (0.7–0.8 in) high, 15–29 mm (0.6–1.1 in) wide, with dark brown tomentum surrounding the horns. Sarcotesta creamy yellow when mature, light brown when ripe. Sclerotesta 17–25 mm (0.7–1 in) long, 17–20 mm (0.7–0.8 in) in diameter, beige, more less smooth except for seven to nine longitudinal ridges. **Male cones** solitary, cylindrical to long conical, 11–31 cm (4.3–12.2 in) long, 2.5–4.5 cm (1–1.8 in) in diameter, light green to olive green at emergence, light yellow to creamy yellow when mature. Peduncle erect, 4–5 cm (1.6–2 in) long, 1–1.8 cm (0.4–0.7 in) in diameter, tomentose. Sporophylls wedge shaped, 14–17 mm (0.6–0.7 in) long, bicornate. Sporophyll face 6–9 mm (0.3–0.4 in) wide. **Habitat:** Oak forest at elevations of about 950 m (3100 ft). **Distribution:** Mexico, Chiapas state, Sierra Madre de Chiapas (Sierra de Soconusco).

I have never seen *Ceratozamia alvarezii* in its habitat, and I am relatively certain that I have never seen a cultivated specimen. Therefore, the following remarks are based on the original description rather than firsthand observations. *Ceratozamia alvarezii* is one of a group of ceratozamias distinguished by long, narrow leaflets. Because of this one might consider that *C. matudae* would be closely related, but *C. alvarezii* has a much smaller, erect, female cone whereas *C. matudae* has a larger cone with a long, slender peduncle. Female cones of *C. matudae* are always decumbent or hanging from the apex of larger stems, never erect. *Ceratozamia norstogii* appears more closely related but its upright, spirally twisted leaves immediately distinguish it from the flat, arching leaves of *C. alvarezii*. I am aware of additional distinctive populations of *Ceratozamia* in Chiapas, Mexico, with narrow leaflets that are definitely neither *C. alvarezii* nor *C. matudae*. These and other populations of *Ceratozamia* in Chiapas are being investigated by Miguel A. Pérez-Farrera, the senior author of *C. alvarezii,* who will no doubt describe several new species from Chiapas.

The cultivation of *Ceratozamia alvarezii* should not be different from other species of the genus. Because of its small size and numerous leaves, *C. alvarezii* would make a fine garden or pot plant, but it is doubtful that any material of this species will be exported from Mexico. It is hoped that seed will be collected and plants grown in Mexico for export.

The conservation status of *Ceratozamia alvarezii* is apparently not favorable. The authors of *C. alvarezii* described it as endangered through clearing the oak forests that make up its habitat for agricultural use. It was also stated that only two small colonies had been seen in one geographic area, indicating that *C. alvarezii* is extremely limited in both distribution and numbers.

Ceratozamia euryphyllidia Vázquez-Torres, Sabato & D. W. Stevenson 1986

PLATES 24, 25, 46, 47

The epithet for *Ceratozamia euryphyllidia* is derived from *euryphyllos,* Greek for broad leaf, referring to the broad leaflets. **Stems** subterranean or shortly emergent, erect, 9–20 cm (3.5–8 in) tall, covered with a rough armor of persistent leaf bases and cataphylls. Cataphylls pubescent, triangular, stipulate, winged at the margin, about 5 cm (2 in) long and 3.5 cm (1.4 in) wide. **Leaves** usually 1–8, rarely as many as 15, stipulate, sparsely pubescent when young, glabrous when mature, 2–3.2 m (6.6–10 ft) long, 38–67 cm (15–26 in) wide, emergent leaves glaucous green, dark green when fully mature, the upper surface with a glaucous bloom. Petiole 60–90 cm (24–36 in) long, terete to subterete with an expanded tomentose base, and heavily armed with large prickles. Rachis straight, semiterete, lower half sparsely armed with prickles, upper half nearly smooth, ending in a conical linear apex 2–7 cm (0.8–2.8 in) long. Leaflets in 6–16 pairs, alternate to subopposite, widely spaced, oblanceolate to widely obovate, the halves unequal, 18–31 cm (7.1–12 in) long, 9–16 cm (3.5–6.3 in) wide, thin textured, narrow at the base, with an attachment 5–10 mm (0.2–0.4 in) wide, abruptly acuminate at the asymmetric apex, with 40–70 dichotomous veins, more prominent when dry, margin entire, often undulate in the lower portion. **Female cones** solitary, erect, cylindrical or slightly conical, 15–22 cm (6–8.7 in) long, 7–13 cm (2.8–5.1 in) in diameter, wine red when immature, brown to dark brown when mature, apex mucronate. Peduncle elongate, 4–10 cm (1.6–3.9 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, gray tomentose. Sporophylls shield shaped, 1.5–3 cm (0.6–1.2 in) long. Sporophyll face transversely hexagonal, 1.5–2 cm (0.6–0.8 in) wide, bearing two stout horns with many fine ridges between them. Sarcotesta whitish, covered with a reddish tomentum except for a prominent white tomentose collar at the attachment. Sclerotesta 2–2.8 cm (0.8–1.1 in) long, 1.6–2 cm (0.6–0.8 in) in diameter, smooth. **Male cones** usually solitary, long cylindrical to elongate conical, about 28 cm (11 in) long and 3 cm (1.2 in) in diameter, greenish red when young, light gray when mature. Peduncle 6–8 cm (2.4–3.2 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, tomentose to woolly. Sporophylls deltoid to cuneate, 7–10 mm (0.3–0.4 in) long, 6–9 mm (0.2–0.4 in) wide, apex shield shaped with two horns 1–2 mm long. Sporangia in a single patch covering the entire lower surface of the sporophyll. HABITAT: Perennially wet rain forest at elevations of 150–510 m (490–1700 ft), usually on limestone pinnacles, ridges, or hilltops in deep shade, associated in one area with dense stands of the bamboo *Olmeca recta.* DISTRIBUTION: Mexico, Veracruz and Oaxaca states, very localized in the Isthmus of Tehuantepec.

It may have surprised some people that as distinctive and beautiful a cycad as *Ceratozamia euryphyllidia* was discovered as late as the 1980s. For those familiar with Mexico, however, it is not surprising, as there are many remote areas to be explored botanically. The most pressing need is to find and describe these sometimes very restricted endemic species before they are eradicated by the continual and rapid clearing of the land for agriculture.

Ceratozamia euryphyllidia, when discovered, consisted of a small population, approximately 30 plants. A few plants and seedlings were removed to the Jardín Botánico Francisco Javier Clavijero, INIREB (Instituto Nacional de Investigaciónes sobre Recursos Bióticos), Jalapa, Veracruz, and subsequently a few seedlings were taken to the Fairchild Tropical Garden, Miami, Florida. It is sad to report that in late 1988 an expedition to the type locality found that the remaining plants had been removed. It is hoped that wherever these plants were taken, they are alive, and that efforts will be made to propagate them.

Three additional populations consisting of about 300 plants were discovered in adjacent Oaxaca in 1996. The new populations are in an otherwise unexplored section of Oaxaca not subjected to land clearing or lumbering. It was noted that *Ceratozamia euryphyllidia* was found only on hilltops and ridges in this new area. Many more similar hills could be seen in the vicinity and the prospects appear good for the discovery of additional populations. Peter Fletcher (pers. comm.) has reported that plants of *C. euryphyllidia* were seldom found more than 30–40 m (100–130 ft) below the crests of the hills and ridges where they occurred. This unusual distribution might be explained by the dispersal of their seeds by birds, possibly the great curassow (*Crax rubra*), which was found to be a dispersal agent for *C. whitelockiana.*

The closest relatives of *Ceratozamia euryphyllidia* appear to be *C. miqueliana, C. whitelockiana, C. zoquorum,* and an unnamed cliff-dwelling species from Tabasco (Plates 48, 49). These species exhibit several of the characteristics of *C. euryphyllidia,* including broad leaflets and the distinctive glaucous lime green foliage. *Ceratozamia miqueliana* does not have leaflets as wide or leaves as long as *C. euryphyllidia.* The Tabasco species differs from *C. euryphyllidia* by its narrower leaflets, shorter leaves, and the color of the female cones, which have a coating of black rather than reddish scales. It differs from *C. whitelockiana* by its broader leaflets and its shorter, pendent rather than upright leaves. The Tabasco plant differs from the three other species in its smaller size, generally unarmed petiole, emergent leaves that have a pinkish petiole and rachis, and distinct veins in the leaflets, made visible by transmitted light.

The scant information I have available regarding *Ceratozamia euryphyllidia* in cultivation would indicate that it is not difficult to maintain when given a warm, humid climate and a shady location. The seedlings taken to the Fairchild Tropical Garden have flourished and produced leaves well over 2 m (6.6 ft) long. *Ceratozamia euryphyllidia* is a spectacular plant that can have as many as 10 suberect, gracefully arching leaves 3 m (10 ft) long. Each leaf is composed of broad leaflets of a beautiful lime green color. Although Vázquez-Torres et al. (1986) stated that emergent leaves were "dark cupric when young," I have not observed this color in any of the individual specimens I have seen. This would be a superb plant for a wind-free and shady garden area in warmer climates. It is hoped that seed will be produced on the cultivated plants of *C. euryphyllidia* and the numbers of this beautiful species increased.

In 1996 Richard Litz, a research botanist at the University of Florida, Homestead, successfully produced *Ceratozamia euryphyllidia* by tissue culturing leaflets from an emergent leaf (Plates 24, 25). There has been a problem with the transition of the plantlets from the sterile test tube to the pot, and all the plantlets have died from fungal infections. When perfected, this procedure may well be the salvation of *C. euryphyllidia* as well as other endangered cycads.

Ceratozamia euryphyllidia is definitely endangered, though additional populations have been located. These other populations are scattered and small, but they give hope that others may be located in the future.

Ceratozamia hildae G. P. Landry & K. L. Wilson 1979

PLATES 13, 50, 51

Ceratozamia hildae is named in honor of Hilda Guerra, daughter of Luciano E. Guerra of Mission, Texas, who was responsible for the first commercial importation of this cycad from Mexico to the United States in 1960.

Stems solitary or in very old plants suckering from the base, almost wholly subterranean, globose or subcylindrical, 8–20 cm (3.2–8 in) long, 5–9 cm (2–3.5 in) in diameter, covered by an armor of persistent leaf bases and tomentose cataphylls. **Leaves** usually one to six, 0.8–1.8 m (2.6–5.9 ft) long, 40 cm (16 in) wide. Petiole 25–45 cm (10–18 in) long, 4–6 mm (0.2 in) in diameter, usually unarmed or lightly armed with scattered small spines. Rachis often slightly twisted near the apex and sometimes curved slightly backward and downward, terete, with two narrow obscure lateral grooves above. Leaflets as many as 48 or more, lanceolate, light green, alternate to subalternate, lowest leaflets single or a clustered pair, the remainder grouped along the rachis in close clusters of three or four, overlapping, thin textured, spirally arranged, with slightly callous, compressed bases, median leaflets 9–15 cm (3.5–6 in) long, 1–3 cm (0.4–1.2 in) wide, length and width slightly increasing from lowest to top leaflet of each cluster, apex acuminate to cuspidate, veins 15–28, scarcely raised on lower surface, margin flat and entire. Mutant forms exist (Plate 13). **Female cones** solitary, cylindrical or globose, 17–19 cm (6.7–7.5 in) long, 7–8 cm (2.8–3.2 in) in diameter, olive green with a light sprinkling of brown tomentum, apex mucronate. Peduncle 8.5–9 cm (3.3–3.5 in) long, 15–17 mm (0.6–0.7 in) in diameter, brown tomentose, unarmed. Sporophylls about 3 cm (1.2 in) long. Sporophyll face 15 mm (0.6 in) high, 25–35 mm (1–1.4 in) wide. Sarcotesta cream to green with a fine sprinkling of dark brown tomentum, turning brown when ripe. Sclerotesta globose to subovoid, flattened, somewhat three- or four-sided, 18–24 mm (0.7–0.9 in) long, 13–18 mm (0.5–0.7 in) in diameter, light tan, smooth. Chalaza prominent, often with a projected apex, surrounded by six to eight radiating short grooves. **Male cones** solitary, long conical, 9–15 cm (3.5–6 in) long, 9–14 mm (0.4–0.6 in) in diameter, slowly reduced in diameter from base to apex, olive green, almost glabrous. Peduncle 9–15 cm (3.5–6 in) long, 5–7 mm (0.2–0.3 in) in diameter, lightly tomentose. Sporophylls cuneate obovate, 3–4 mm long, with two small horns at the upper margin. Sporophyll face 1 mm high, 3–4 mm wide. Sporangia in a single patch covering the underside of the sporophyll. **Habitat:** Oak-pine forest at elevations of 300–925 m (1000–3000 ft) in heavy black clay and among limestone rocks, associated with two species of *Brahea, Dioon edule,* and in some areas with *Ceratozamia latifolia* and *Zamia vazquezii.* **Distribution:** Mexico, Querétaro state, region of the Huasteca Potosina near the Río Santa María.

Ceratozamia hildae is one of the most remarkable of the American cycads. Discovered by Antonio Martínez, a nurseryman in San Luis Potosí, Mexico, it was first introduced into the United States in early 1960 by a commercial plant collector, Luciano E. Guerra, of Mission, Texas, it was immediately in great demand. It is unbelievable that it took 18 years after its introduction before it was described as a new species. It is a dwarf plant with a small subterranean stem, producing relatively long, upright leaves. The unique aspect of this cycad is the clustering of the leaflets along the rachis, a feature not found in any other species of *Ceratozamia.*

Ceratozamia hildae is easily grown as a pot plant or in the ground in climatically suitable areas. It will withstand several degrees of frost without apparent damage and can also tolerate a great deal of sunlight. Established plants usually produce both cones and leaves each year, but stem growth is slow. Exceptions to this are in tropical areas where these cycads produce multiple crowns and will sustain 30–40 or more leaves and multiple cones. The growth rate in cultivation is greatly in excess of the plants in habitat.

I have observed several habitat-collected plants that appear to be natural hybrids between *Ceratozamia hildae* and *C. latifolia.* These plants appear more or less like *C. hildae* but have shorter leaves and leaflets of a much heavier texture. Some of the hybrid plants have reddish brown emergent leaves, similar to those of some specimens of *C. latifolia.* This reddish color persists on the new leaves for more than a year, particularly on the rachis and leaflet bases. No other hybrids are known to occur, but several artificial hybrids between *C. hildae* and other species of *Ceratozamia* have been made. They are too young to permit comment on leaf character.

Given the conditions of a tropical climate or conservatory culture, seed of *Ceratozamia hildae* is quite easily produced. For some reason the viability of this artificially pollinated seed has proved to be quite unpredictable and the percentage of fertile seed is usually low. Hand pollination is necessary, as the natural insect pollinators are absent. This poses no great problem, and seed can be artificially produced using one of the methods outlined in Chapter 5.

Because of its small size and beauty, *Ceratozamia hildae* has been a popular cycad since its introduction. Its popularity has led to near extinction in the wild. Untold thousands of these small cycads have been exported to various countries, and the demand has not diminished. The elevation of the genus *Ceratozamia* to Appendix I of

CITES has finally halted the export of this cycad from Mexico. The remaining populations of *C. hildae* are small and scattered, and it must be considered one of the most endangered of the ceratozamias.

Ceratozamia kuesteriana Regel 1857

PLATES 52, 53

Ceratozamia kuesteriana is named in honor of Baron K. von Kuester, a nineteenth century plant collector. **Stems** solitary, rarely branched but often suckering from the base, subterranean, 15–20 cm (6–8 in) long, 10–12.5 cm (4–5 in) in diameter, covered by old leaf bases and cataphylls but with a relatively smooth surface. **Leaves** in mature plants usually three to five, emergent and immature leaves dark golden brown and lightly tomentose, mature leaves glossy dark green and glabrous, 1–1.8 m (3.3–5.9 ft) long, 47.5–62.5 cm (19–25 in) wide, flat to moderately keeled, not twisted. Petiole 17.5–30 cm (7–12 in) long, 6–8 mm (0.2–0.3 in) in diameter, generally unarmed but occasionally with a few small spines. Rachis subterete, grooved on either side above. Leaflets in 35–45 pairs, linear lanceolate, 10–22 cm (4–8.7 in) long, 6–15 mm (0.2–0.6 in) wide, channeled above, seven- to nine-veined, the veins prominent beneath and obscure above, margin entire and slightly revolute. **Female cones** solitary, globose to short cylindrical, 11.3–17.5 cm (4.4–7 in) long, 5–7.5 cm (2–3 in) in diameter, olive green, lightly tomentose, apex mucronate. Peduncle densely tomentose, 5–7.5 cm (2–3 in) long, 1.3–2 cm (0.5–0.8 in) in diameter. Sporophylls 2–2.3 cm (0.8–0.9 in) long. Sporophyll face 8–10 mm (0.3–0.4 in) high, 23–25 mm (0.9–1 in) wide, the horns short and connected by a more or less straight transverse ridge 10–13 mm (0.4–0.5 in) long. Sarcotesta cream colored when mature, rapidly turning brown when the seed shed from the cone. Sclerotesta subovoid to globose, 17–22 mm (0.7–0.9 in) long, 13–17 mm (0.5–0.7 in) in diameter, smooth with a few shallow, indistinct, longitudinal grooves. Chalaza 4–6 mm (0.2 in) in diameter, consisting of six to eight shallow pits. **Male cones** solitary, erect, long conical, 22.5–30 cm (9–12 in) long, 28–35 mm (1.1–1.4 in) in diameter, lightly tomentose but appearing almost glabrous, apex mucronate. Peduncle 5–15 cm (2–5.9 in) long, 1–1.3 cm (0.4–0.5 in) in diameter, densely tomentose. Sporophylls 8–11 mm (0.3–0.4 in) long, with two short horns connected by a transverse ridge. Sporophyll face pyramidal truncate, 2–6 mm (to 0.2 in) high, 7–10 mm (0.3–0.4 in) wide, projecting 4–7 mm (to 0.3 in). Sporangia in a single patch covering the entire underside of the sporophyll. **Habitat:** Steep mountain slopes covered by pine-oak forest, in deep soil well mixed with limestone rocks, at elevations of 1100–1800 m (3600–5900 ft). Rainfall averages 1000 mm (40 in) annually, falling mainly in summer. Daytime temperature range is 16–28°C (61–82°F), the lows occurring in December–January and the highs in August–September. **Distribution:** Mexico, Tamaulipas state, along the Sierra Madre Oriental between Tula and Gómez Farías.

Ceratozamia kuesteriana was described by Eduard August von Regel in 1857 from specimens collected by Wilhelm Karwinsky in 1841. It was then lost to science. Rediscovered about 1965 by a commercial plant collector, Luciano E. Guerra of Mission, Texas, who had no idea of its botanical identity, Guerra referred to the cycad as *Ceratozamia* "Rancho del Cielo" after one of the locations where it was collected. In 1981 three plant taxonomists, Aldo Moretti and Sergio Sabato of Italy, and Mario Vázquez-Torres of Mexico, while researching various ceratozamias, noted the similarity between Karwinsky's collection of *C. kuesteriana* and two more recent collections made in Tamaulipas, Mexico. These later populations proved to be the long-lost *C. kuesteriana.* Their fieldwork made possible the proper identification of previously collected, but unnamed, specimens.

Ceratozamia kuesteriana is a handsome cycad if grown well, and its small size makes it a fine garden and pot plant. The cycad is quite cold tolerant and hardy to several degrees below freezing. Unlike most other species of the genus, *C. kuesteriana* can normally withstand direct sunlight without burning, though it will also grow well in shady locations. Because of their wider and flatter leaflets, seedlings look nothing like the mature plants. As the plant reaches maturity, leaflets become narrower and start to exhibit the deep channel so typical of this species. Seedlings grow quite rapidly, and mature foliage is produced in a very few years. The cones are small, easily pollinated, and interesting to watch as they mature.

The conservation status of *Ceratozamia kuesteriana* is not good. As a result of prolonged collecting, the numbers of this species in the wild have been drastically reduced. Now that *Ceratozamia* has been elevated to Appendix I of CITES, export of the genus has come to a halt. CITES protection, however, does not help protect habitats where the land is being cleared for agriculture. It is hoped that the Mexican government will take steps to protect some of the rarer species of *Ceratozamia* where they still survive. *Ceratozamia kuesteriana* must be considered endangered because of its restricted habitat, small numbers, and continuing land clearance.

Ceratozamia latifolia Miquel 1849

PLATE 54

The epithet for *Ceratozamia latifolia* is derived from *latifolius,* Latin for broad leaf, though *latifoliolata,* broad leaflet, would have been more fitting. **Stems** solitary but occasionally suckering from the base, usually subterranean but often emerging above ground or growing in limestone crevices, 12.5–25 cm (5–10 in) long, 10–11.3 cm (4–4.4 in) in diameter, the exterior of the persistent leaf bases slightly wrinkled and light brown. **Leaves** usually one to seven, dark green, slightly arching, 0.9–1.5 m (3–4.9 ft) long, 35–50 cm (14–20 in) wide, flat. Petiole 35–40 cm (14–16 in) long, 8 mm (0.3 in) in diameter, base stipulate, lightly armed with a few scattered, short spines, median leaflets stiff and leathery, unequally drawn out, slightly overlapping in a downward direction, 20–30 cm (8–12 in) long, 33–43 mm (1.3–1.7 in) wide, margin entire and revolute, plants growing in deep shade with wider spacing between the leaflets and the leaflets appearing flatter. **Female cones** solitary, at first erect, leaning as the cone matures, short cylindrical, 15–16.5 cm (6–6.5 in) long, 6.5–7.5 cm (2.6–3 in) in diameter, dull olive green with a scattering of dark brown scales that are most numerous at the center of the sporophyll. Peduncle 2–4 cm (0.8–1.6 in) long, 1–1.4 cm (0.4–0.6 in) in diameter, densely tomentose. Sporophyll face 16 mm (0.6 in) high, 25–28 mm (1–1.1 in) wide, more or less flat with a median ridge connecting the two flat, slightly twisted horns. Sarcotesta white when seed is first shed but turning brown and soft in 24–48 hours. Sclerotesta subovoid to globular, 20–24 mm (0.8–0.9 in) long, 11–16 mm (0.4–0.6 in) in diameter, light tan, smooth, slightly three-sided with a few indistinct longitudinal grooves. Chalaza distinct, slightly protecting with a circle of pits 3–4 mm in diameter, surrounded by shallow radiating grooves. **Male cones** solitary, erect, long conical, 20–25 cm (8–10 in) long, 3 cm (1.2 in) in diameter, dull olive green, apex mucronate. Peduncle 3.5–4 cm (1.4–1.6 in) long, 1 cm (0.4 in) in diameter, densely tomentose. Sporophylls flattened and wedge shaped, the two small horns slightly deflexed, 7–8 mm (0.3 in) long. Sporophyll face 3 mm high, 7–8 mm (0.3 in) wide. Sporangia in a single patch confined to the lower surface. **Habitat:** Steep limestone hillsides and canyons at elevations of about 500 m (1600 ft) under dense wet forest. Rainfall averages 1260 mm (50 in) annually, falling mainly in summer but frequent throughout the year. **Distribution:** Mexico, San Luis Potosí state, vicinity of Xilitla and Tamazunchale.

Friedrich Anton Wilhelm Miquel described *Ceratozamia latifolia* in 1849 from plants collected "in Mexico." At that time, specimens found their way to several botanical gardens and into the conservatories of numerous collectors. Since then, many hundreds, if not thousands, of *C. latifolia* have been imported into the United States, and *C. latifolia* must be one of the commonest species of *Ceratozamia* in cultivation. Its medium size, ready availability, and interesting leaves have made it a popular pot plant in conservatories, and a garden plant in areas where weather conditions allow its use outdoors. As with other species of *Ceratozamia,* this species is easy to cultivate. It does well in areas of low light and can be used successfully as a houseplant if kept out of heavy-traffic areas that might cause damage to the somewhat brittle leaflets.

The habitat of *Ceratozamia latifolia* is mountainous and steep. This species grows in an almost constantly wet forest area. Rain and mist are frequent even in the drier winter months. The area is composed predominantly of limestone; some of which has been weathered into strange-looking spires covered with a lush growth of ferns, philodendrons, and other tropical plants. *Ceratozamia latifolia* can be found growing in cracks in the limestone, or in small pockets that the constant leaf debris has filled with humus. I have even seen this species growing in trees where the seed was no doubt deposited by a bird or other animal while feeding on the sarcotesta.

Ceratozamia latifolia seems to be secure. Even though many hundreds of plants have been collected in the past, the species is not uncommon in its habitat. It can still be seen overhanging main roads as one travels through the mountains. Regeneration from seed is good, and seedlings are found in most areas. Although considerable habitat has been lost to land clearance for banana and coffee production, the steep rocky areas this cycad prefers are in most cases unfit for agriculture. *Ceratozamia latifolia* is without doubt threatened but not yet endangered.

Ceratozamia matudae Lundell 1939

PLATES 55–57

Ceratozamia matudae is named in honor of Eizi Matuda (1894–1978), Japanese-born botanist who immigrated to Mexico, became a botanical explorer, and discovered this cycad in southern Chiapas. **Stems** solitary, usually unbranched, 30–50 cm (12–20 in) long, 15–20 cm (6–8 in) in diameter, covered by old leaf bases and cataphylls. **Leaves** about 10 on a mature plant, glabrous, 0.8–1.2 m (2.6–3.9 ft) long, 40–65 cm (16–26 in) wide, flat. Petiole subterete, 35–40 cm (14–16 in) long, armed with scattered short, stout spines. Rachis flattened, grooved on the upper side where leaflets attach, armed with a few short, stout prickles. Leaflets in 23–44 pairs, linear lanceolate, slightly falcate, the basal and apical ones shortest, widest above the constricted base, gradually tapering to a long slender point, leathery, yellow-green, glossy above, yellow at their attachment to the rachis, 6- to 11-veined, the veins prominent below and obscure above, median leaflets 20–38 cm (8–15 in) long, 7–15 mm (0.3–0.6 in) wide, margin flat and entire. **Female cones** solitary, decumbent, short cylindrical, 15–17 cm (6–6.7 in) long, 9 cm (3.6 in) in diameter. Peduncle generally longer than the cone, 15–22 cm (6–8.7 in) long, 8–10 mm (0.3–0.4 in) in diameter, rarely armed, at first red, scaly, glabrescent with age. Sporophyll face transversely hexagonal, 1.8–2 cm (0.7–0.8 in) high, 3–3.5 cm (1.2–1.4 in) wide, base tomentose, red, scaly, medially bicornate, the horns strongly spreading, glabrous, their base red, scaly. Sarcotesta white to cream when ripe, soon turning brown after being shed. Sclerotesta ovoid, about 30 mm (1.2 in) long and 23 mm (0.9 in) in diameter. **Male cones** solitary, decumbent, oblong cylindrical, abruptly mucronate, 8–16 cm (3.2–6.3 in) long, 3–4.5 cm (1.2–1.8 in) in diameter, slightly narrowed toward the apex, dull green with a sprinkling of brown scales. Peduncle 8–11 cm (3.2–4.3 in) long, covered with small red scales. Sporophylls 10–21 mm (0.4–0.8 in) long, medially bicornate, the horns strongly spreading, 1.5–4 mm long, apex pointed downward. Sporophyll face 3–4 mm high, 8–11 mm (0.3–0.4 in) wide, broadest at the center. Sporangia in a single somewhat heart-shaped patch that may roll up over the edges of the sporophyll. **Habitat:** Wet broadleaved forest on very organic clay soil, generally on north-facing slopes, at elevations of 1000–2100 m (3300–6900 ft). Rainfall averages 1500–2000 mm (59–79 in) annually, falling mainly in summer. Temperatures average 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Mexico, Chiapas state, southwestern portions of the Sierra Madre de Chiapas (Sierra de Soconusco), described originally from the northern slopes of Mount Ovando.

Ceratozamia matudae was collected by Eizi Matuda in 1937 and described by Cyrus Longworth Lundell in 1939. Matuda unknowingly collected two genera, one a *Ceratozamia,* the other a *Zamia,* which he mistakenly considered to be the same plant—the leaves and leaflets of both plants are amazingly similar. The *Zamia* was described in 1988 as *Z. soconuscensis.* No known living material of *C. matudae* was in cultivation until 1985 when the type locality was revisited and plants collected.

The rediscovery of *Ceratozamia matudae* and the subsequent close examination of living plants made it quite clear that specimens collected in northern Chiapas, Mexico, and referred to *C. matudae* were incorrectly identified. Apparently, *C. matudae* is restricted to the Soconusco district in southwestern Chiapas and is quite distinct from the ceratozamias of northern Chiapas. The northern plants have dull, dark green, narrower leaflets and heavily armed petioles as opposed to the glabrous, yellowish green leaflets with yellow attachments and lightly armed petioles of *C. matudae. Ceratozamia matudae* may also be readily separated from the other ceratozamias by the much longer peduncles of both female and male cones and the larger microsporophylls.

Ceratozamia matudae has proved to be easy to grow and does not seem to present any horticultural problems. A moist, loose soil containing a large percentage of organic material is preferred. Judging from its elevational range it should be somewhat cold tolerant. The other species of *Ceratozamia,* with the exception of the papery leaved species such as *C. euryphyllidia, C. miqueliana,* and *C. whitelockiana,* display a considerable degree of cold hardiness, and no leaf damage occurs at temperatures slightly below freezing. *Ceratozamia matudae* is a handsome, medium sized cycad that would no doubt be popular in collections or landscapes if sufficient numbers could be made available.

The principal population of *Ceratozamia matudae* is thought to be restricted to Mount Ovando, where it was discovered. Although the plants are somewhat common locally, their total number is probably quite small. No information is available as to regeneration in habitat. The habitat has been reduced by the clearing of land for corn and coffee production, and lumbering. For these reasons the species must be considered threatened, and we must hope that measures will be taken to ensure its survival.

Ceratozamia mexicana Brongniart 1846

PLATES 58, 59

The epithet for *Ceratozamia mexicana* refers to Mexico, this cycad's country of origin. **Stems** solitary or sometimes suckering from the base, globose or cylindrical, to 1 m (3.3 ft) tall and 20 cm (8 in) in diameter, dark brown. Cataphylls triangular acuminate, about 7.5 cm (3 in) long and 6 cm (2.4 in) wide at the base. **Leaves** numerous, arching and spreading, 1.5–2 m (4.9–6.6 ft) long, to 75 cm (30 in) wide. Petiole 30–50 cm (12–20 in) long, 1.5 cm (0.6 in) in diameter, moderately to heavily armed with numerous spines 3–4.5 mm long. Leaflets in 40–60 pairs, long lanceolate, straight or somewhat falcate, 28–40 cm (11–16 in) long, 1.5–2 cm (0.6–0.8 in) wide, gradually acuminate toward the pungent apex, glossy medium green above, lighter below, moderately keeled, margin entire and moderately revolute. **Female cones** solitary, at first erect, then leaning, cylindrical with a mucronate apex, 26–35 cm (10–14 in) long, 9–12 cm (3.5–4.7 in) in diameter, medium dull green. Peduncle 6–10 cm (2.4–3.9 in) long, 2 cm (0.8 in) in diameter. Sporophylls bicornate, 18–25 mm (0.7–1 in) high, 27–35 mm (1.1–1.4 in) wide, the center portion of the sporophyll face moderately sprinkled with blackish scales, the outer edge with grayish white tomentum. Sarcotesta when mature at first white with lightly scattered brown tomentum, turning medium brown as it ripens after falling from the cone. Sclerotesta normally more or less three-sided and gradually reduced in size toward the apex, 23–30 mm (0.9–1.2 in) long, 15–18 mm (0.6–0.7 in) in diameter, tan, more or less smooth except for a few indistinct shallow longitudinal grooves. Chalaza not elevated or very slightly so, 5–6 mm (0.2 in) in diameter. **Male cones** solitary, erect, long conical, 38–43 cm (15–17 in) long, 7–8 cm (2.8–3.2 in) in diameter, medium green, apex somewhat blunt. Peduncle 7.5–10 cm (3–4 in) long, 2.5 cm (1 in) in diameter, the surface densely light brown tomentose. Median sporophyll face 6 mm (0.2 in) high, 15–17 mm (0.6–0.7 in) wide, always bicornate, the horns about 3 mm long. Sporangia covering the entire lower surface of the sporophyll. **Habitat:** Steep hillsides or canyon walls in loose, very organic soil under cover of pine-oak forest at elevations of about 1550 m (5100 ft). Rainfall averages 2250 mm (89 in) annually, falling mostly in summer. **Distribution:** Mexico, Veracruz state, northeast of Jalapa.

Ceratozamia mexicana is the type species of *Ceratozamia* and was named by Adolphe Théodore Brongniart in 1846 at the same time he described the genus *Ceratozamia.* The collection site was given only as Mexico, but the excellent drawings illustrating the species leave little doubt that it is the common species found near Jalapa, Veracruz, Mexico. In 1846 Veracruz was the primary seaport on the Gulf Coast of Mexico, therefore many botanists from Europe used it as a starting point for their expeditions. The *Ceratozamia* habitat near Jalapa was a mere 2 days' travel by horseback from the port of Veracruz. This proximity no doubt led to the early discovery of *Ceratozamia.*

The taxonomy of *Ceratozamia mexicana* is under examination by various researchers. At present a number of forms are lumped into the concept of *C. mexicana.* I believe that with additional investigation some of these will emerge as distinct species.

Ceratozamia mexicana grows extremely well in cultivation and is well represented in botanical gardens around the world. Its ability to grow in low light also makes it a favorite with collectors and interior decorators. It can be used as a houseplant and will thrive with little light and in a dry atmosphere. The leaflets are not spiny, so it is safe in areas of heavy traffic. The only negative factor is its brittle leaflets, which are stiff and can be broken away from the rachis quite easily. For this reason plants should receive protection from people or animals pushing by them. A constantly damp growing medium, high in organic matter and with excellent drainage, is preferred. In the wild, plants can sometimes be found growing in almost pure leaf mold. Light applications of fertilizer during the warmer months of the growing season will maintain the dark, glossy green foliage. *Ceratozamia mexicana* is frost tolerant and will show no foliar damage at several degrees below freezing. This is a cycad that must be protected from strong wind, which tends to bend or break away the brittle leaflets. This species grows well and reasonably rapidly from seed, but seed is not generally available.

The range of *Ceratozamia mexicana* has been severely diminished since the mid-1960s. Its habitat is well suited to the production of coffee and bananas, and large areas have been cleared for this purpose. The remaining populations are of sufficient size to ensure its continued existence. As land clearance in the habitat of *C. mexicana* continues, that will pose a serious threat to its survival. For these reasons *C. mexicana* must be considered threatened.

Ceratozamia microstrobila Vovides & J. D. Rees 1983

PLATES 60, 61

The epithet for *Ceratozamia microstrobila* is derived from *micro-,* Greek for small, and *strobilus,* cone, referring to the small size of the cones. **Stems** subterranean or sometimes elevated slightly above the soil, ovoid to subcylindrical, to 24 cm (9.5 in) long and 10 cm (4 in) in diameter, covered by light brown persistent leaf bases and cataphylls. Cataphylls triangular, tomentose, 3–5 mm (to 0.2 in) long. **Leaves** usually one to four, slightly arching, dark glaucous green, to 70 cm (28 in) long, 25–30 cm (10–12 in) wide, flat, emergent leaves dark reddish brown, slightly glaucous, the glaucousness persisting the first year. Petiole 20–30 cm (8–12 in) long, 3–5 mm (to 0.2 in) in diameter, unarmed, medium brown, stipulate and tomentose at the base. Leaflets in 6–12 pairs, broad lanceolate, leathery, glaucous green to green, 15–18 cm (6–7.1 in) long, 2.8–3.2 cm (1.1–1.3 in) wide, veins obscure, margin entire, subrevolute, and acute at the apex. **Female cones** solitary, ovoid, 6–9 cm (2.4–3.5 in) long, 4.4–5 cm (1.7–2 in) in diameter, greenish brown. Peduncle 18–60 mm (0.7–2.4 in) long, 12 mm (0.5 in) in diameter, moderately tomentose, unarmed. Sporophyll face 13 mm (0.5 in) high, 17–21 mm (0.7–0.8 in) wide, tomentose at the edges, the horns 2 mm long and spaced 14 mm (0.6 in) apart. Sarcotesta white to cream, greenish where exposed to light between the sporophylls, turning brown when ripe. Sclerotesta ovoid elongate, 16–18 mm (0.6–0.7 in) long, 12–14 mm (0.5–0.6 in) in diameter, tan, more or less smooth. **Male cones** solitary, more or less cylindrical, 8–17 cm (3.2–6.7 in) long, 15–23 mm (0.6–0.9 in) in diameter, gradually narrowing from base to apex, brown. Peduncle 25–50 mm (1–2 in) long, 5–8 mm (0.2–0.3 in) in diameter, tomentose. Sporophylls 5–8 mm (0.2–0.3 in) long, the horns about 2 mm long, 5 mm (0.2 in) apart. Sporophyll face 2 mm high, 5–7 mm (0.2–0.3 in) wide. Sporangia in a single patch covering the underside of the sporophyll and continuing up over the sporophyll edge. **Habitat:** Oak woodland and low deciduous forest in shallow reddish clay soil rich in humus, at elevations averaging 850 m (2800 ft), associated in some areas with *Dioon edule, Zamia vazquezii,* and *Sabal.* **Distribution:** Mexico, San Luis Potosí state, municipality of Ciudad del Maíz.

Ceratozamia microstrobila is based on a specimen collected November 7, 1974, by John D. Rees. Later investigations by Andrew P. Vovides and Rees in 1977 convinced them that this cycad was an undescribed species, leading to its description in 1983.

Ceratozamia microstrobila is an interesting cycad because of its small size and very small cones. Three to five leaves seem to be the normal complement in cultivation, even after a number of years. Usually in alternate years a cone is produced instead of leaves. The best growth is obtained when this species is planted in a position of bright shade or morning sun. In cultivation, plants of coning size could probably be attained in 6–8 years from seed. *Ceratozamia microstrobila* does well as a pot plant or in the ground and will withstand several degrees of frost without damage to the foliage.

More recently, at least one taxonomist has suggested that *Ceratozamia microstrobila* is synonymous with *C. latifolia,* stating that depending on conditions of light and humidity, *C. latifolia* could “turn into” *C. microstrobila* and vice versa. This is definitely not the case, and plants cultivated for years remain true to species and are easily distinguished. It is true that ceratozamias are very plastic in their leaf growth response when subjected to dark and humid conditions as opposed to light and dry conditions, but one must grow both species under the same conditions to make a valid comparison. When this is done with *C. latifolia* and *C. microstrobila,* the two species can be separated quite easily.

In its habitat this small cycad is usually found wedged between rocks or tree roots, growing in well-shaded situations. Wild plants are not the least bit pretty, as the leaves are usually damaged or dead. Receiving brighter light, their appearance is greatly improved, and sometimes even cones are found.

Seed regeneration in the wild is quite low, and seedlings are unusually scarce. As with other species of this genus, clearing is making inroads on the colonies still in existence. As *Ceratozamia microstrobila* is not a particularly handsome species, it has not been widely collected for commercial use. *Ceratozamia microstrobila* must be considered threatened, mainly because of habitat destruction.

Ceratozamia miqueliana H. Wendland 1854

PAGE 57, PLATE 62

Ceratozamia miqueliana is named in honor of Friedrich Anton Wilhelm Miquel (1811–1871), Dutch botanist who served as director of the Rotterdam Botanical Gardens, 1835–1846, and the Amsterdam Botanical Gardens, 1846–1859. **Stems** subterranean or shortly emergent, to 30 cm (12 in) tall and 17.5 cm (6.9 in) in diameter but usually smaller. Persistent leaf bases very woody, wrinkled, and slightly reddish brown. **Leaves** usually 5–10 in mature plants, arching, 1.2–1.8 m (3.9–5.9 ft) long, 52.5–60 cm (21–24 in) wide, emergent foliage glaucous lime green, mature foliage glaucous green with the glaucous waxy coating persisting for some time, then medium green in old age, in habitat, the growth of mosses and lichens on the surface of older leaves tending to obscure both the outline and the actual color of the leaflets. Petiole 40–48 cm (16–19 in) long, 7–13 mm (0.3–0.5 in) in diameter above the swollen, tomentose, stipulate base, heavily armed with curved spines to 1 cm (0.4 in) long that sometimes continue for some distance up the rachis. Leaflets in 15–20 pairs, opposite to alternate, somewhat papery, 20–30 cm (8–12 in) long, 5–7 cm (2–2.8 in) wide, unequally and abruptly drawn out, margin entire and slightly revolute. **Female cones** solitary, cylindrical, erect, 11–15 cm (4.3–6 in) long, 8.7–10 cm (3.4–4 in) in diameter, olive green, apex mucronate. Peduncle

3–4 cm (1.2–1.6 in) long, 1.5–3 cm (0.6–1.2 in) in diameter, covered with brown hair. Sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face 1.5–2 cm (0.6–0.8 in) high, 2.5–4 cm (1–1.6 in) wide, irregularly hexagonal, finely gray tomentose especially along the margin, bicornate, the horns on a raised portion of the face, their tips bent downward, with a small rudimentary horn arising between the main horns. Sarcotesta white to cream at shedding but turning soft and brown when fully ripe. Sclerotesta ovoid to globose, somewhat three-sided, 22–25 mm (0.9–1 in) long, 16–18 mm (0.6–0.7 in) in diameter, light tan, with seven to nine indistinct longitudinal grooves. Chalaza slightly raised, 4–5 mm (0.2 in) in diameter. **Male cones** solitary, long conical, 20–25 cm (8–10 in) long, 3–4.5 cm (1.2–1.8 in) in diameter, apex mucronate. Peduncle 25–40 mm (1–1.6 in) long, 12–17 mm (0.5–0.7 in) in diameter, densely covered with light brown to gray tomentum. Sporophylls 8–10 mm (0.3–0.4 in) long, bicornate, the horns directed straight out from the cone axis. Sporophyll face wedge shaped, 3–5 mm (to 0.2 in) high, 7–10 mm (0.3–0.4 in) wide, narrowest at its apex, olive green, with a sparse, even covering of blackish tomentum. Sporangia covering the entire lower surface of the sporophyll. **Habitat:** Dense rain forest or on raised ground in swampy areas at elevations of 5–500 m (16–1600 ft). Rainfall averages 2000 mm (79 in) annually, falling mainly in summer. Weather is generally hot and humid. **Distribution:** Mexico, in Veracruz, Tabasco, and Chiapas states.

Hermann Wendland described *Ceratozamia miqueliana* in 1854 from plants cultivated in Europe. At the time, Wendland did not even know its country of origin. In later years, *C. miqueliana* was rediscovered in Tabasco, Mexico, and later in Veracruz.

Ceratozamia miqueliana is one of the most beautiful of the ceratozamias. Its long, arching leaves, with their distinctive glaucous lime green color and broad leaflets, make *C. miqueliana* difficult to surpass for decorative beauty. It is an easy cycad to grow if given a shady location, a soil rich in humus, and protection from frost and wind. It is reasonably cold tolerant but is one of the more cold sensitive of the ceratozamias. It excels in greenhouse culture, as an indoor plant, or outdoors in more tropical climates.

One problem met with *Ceratozamia miqueliana* is that the emergent leaves are very attractive to slugs and snails—a new set of leaves may be completely destroyed in a single night! On occasion, I have seen specimens with half-grown leaves that have the petiole eaten away at the base, causing the whole leaf to shrivel and die. Other pests include scale insects, mealybugs, and grasshoppers. If a scale infestation is present when new leaves emerge, the leaflets can be deformed and the crown made very unsightly.

The nearest relatives of *Ceratozamia miqueliana* are *C. euryphyllidia, C. whitelockiana, C. zoquorum,* and an unnamed cliff-dwelling species from Tabasco, which are compared in the remarks under *C. euryphyllidia.*

Ceratozamia miqueliana grows in rain forest and at relatively low elevations. The plants from Tabasco are found growing in swampy areas on small islands or raised areas. The colonies investigated in Chiapas and Veracruz were generally found growing on steep slopes under heavy rain forest cover in very organic to heavy clay soils. In the Chiapas colony, which I discovered in 1970, *C. miqueliana* was mixed with ferns having a similar leaf form, making the cycads difficult to locate. In its habitat, the leaflets of *C. miqueliana* are usually somewhat disfigured by chewing insects and are covered by a growth of mosses and lichens, making them very difficult to identify at distance.

Ceratozamia miqueliana is not secure. In spite of the fact that it appears to cover a huge range in three Mexican states, the populations are small and widely scattered, and regeneration does not seem to be prolific. There is also the chance that these disjunct populations may not be the same species, and additional fieldwork is needed to clarify this question. Because of the beauty of this species, many hundreds of plants have been collected as ornamentals. *Ceratozamia miqueliana* must be considered extremely endangered. It is hoped that remaining populations can be protected from overcollecting and other forms of destruction. *Ceratozamia miqueliana* should be considered a prime species for artificial propagation.

Ceratozamia mirandae Pérez-Farrera, Vovides & Iglesias 2001

PLATES 63, 64

Ceratozamia mirandae is named in honor of Faustino Miranda, researcher of the flora of Chiapas. **Stems** subterranean or in older specimens with a portion of the stem above ground, subcylindrical to cylindrical, 32–105 cm (13–41 in) long, 9–28 cm (3.5–11 in) in diameter, with a rough covering of old leaf bases and cataphylls. Cataphylls stipulate, tomentose, 3–8 cm (1.2–3.1 in) long, 1.2–3.8 cm (0.5–1.5 in) wide. **Leaves** 6–23, arching, medium green, 0.8–1.7 m (2.6–5.6 ft) long, 45–55 cm (18–22 in) wide, flat to lightly keeled, emergent leaves brown and densely tomentose, green and glabrous when mature.

Petiole 20–59 cm (8–23 in) long, terete to subterete, stipulate at the base, armed with numerous spines. Leaflets in 50–80 pairs, leathery, linear lanceolate, subfalcate, opposite to subopposite, rarely alternate, median leaflets 20–50 cm (8–20 in) long, 3–7 mm (to 0.3 in) wide, narrowing abruptly at the base and gradually toward the apex, five- or six-veined, lightly channeled. Female cones solitary, cylindrical, 26–48 cm (10–19 in) long, 9–12 cm (3.5–4.7 in) in diameter, olive green, apex mucronate. Peduncle tomentose, 5.5–14 cm (2.2–5.5 in) long, 1.5–2 cm (0.6–0.8 in) in diameter. Sporophylls 5.3–5.8 cm (2.1–2.3 in) long. Sporophyll face 22–25 mm (0.9–1 in) high, 15–35 mm (0.6–1.4 in) wide, with two stout horns projecting from its center. Sarcotesta white to cream, slightly pubescent, brown when ripe. Sclerotesta irregularly ovoid, 20–35 mm (0.8–1.4 in) long, 17–19 mm (0.7 in) in diameter, light tan. Chalaza prominent. Male cones solitary, long conical, 26–57 cm (11–22 in) long, 4.2–8 cm (1.7–3.2 in) in diameter, tapering slightly toward the mucronate apex. Peduncle elongate, 3–11.5 cm (1.2–4.5 in) long, 2–3 cm (0.8–1.2 in) in diameter, densely black tomentose. Sporophylls broadly wedge shaped, 12–15 mm (0.5–0.6 in) long, apex with two horns 1–3 mm long that are either straight or bent downward. Sporophyll face 2–3 mm high, 5–8 mm (0.2–0.3 in) wide, projecting about 4 mm. Sporangia in a single patch. Habitat: Steep slopes in pine-oak woodland at elevations of 900–1250 m (3000–4100 ft). Distribution: Mexico, Chiapas state, mountain slopes of the Sierra Madre del Sur and Sierra de Niltepec, also reported in Oaxaca state.

Confusion has reigned among botanists and collectors over the true identity of *Ceratozamia norstogii* since it was described in 1982. This confusion arose because of the close proximity of the populations of *C. norstogii* to what would be described as *C. mirandae.* Not only that, but these two very distinct species share the same type of habitat, pine-oak woodland. Add to this the fact that both have very narrow leaflets, and one can understand how the two could become confused. Seen side by side the two species can be easily separated. *Ceratozamia norstogii* has leaves that are plumelike in appearance. The leaves are held almost vertically and are normally twisted through one-third to two revolutions. The leaves of *C. mirandae* are not twisted but flat or lightly keeled, arching, and very regular. The two species inhabit the same mountainous area and are found quite commonly in the Sierra Madre del Sur and the Sierra de Niltepec, Chiapas, Mexico, some 50 km (30 miles) apart. They are thought to continue through the mountains between these two localities, and if so, have an extensive range.

There are relatively few specimens of *Ceratozamia mirandae* in cultivation. This is no doubt the result of a combination of its remote habitat, a great distance from the U.S. border. In the past, commercial collectors of Mexican plants were centered around Brownsville, Texas. They worked the Gulf Coast of Mexico where the distances were not so great and the roads in better condition. For whatever reason, not many specimens of *C. mirandae* found their way to countries outside Mexico. In more recent years, seed of *C. mirandae* has become available commercially, allowing this species to become more widely grown.

Cultivation of *Ceratozamia mirandae* is not difficult. The plants are undemanding but must be protected from hard freezes and given a semishaded environment. As for most cycads, well-drained soil and sufficient water and fertilizer are all that is required. This cycad grows well from seed but not as rapidly as species such as *C. mexicana* and *C. robusta.* The medium size of *C. mirandae* makes it a fine plant for containers or gardens of restricted size.

Ceratozamia mirandae is still plentiful in the wild, no doubt because of its remote habitat. Its range covers a large area of the Sierra Madre del Sur and Sierra de Niltepec, indicating that there are still large numbers of this species in habitat. Access to most of its range is by foot or horseback, protecting it from all but the most rapacious collectors. For these reasons, *C. mirandae* is not considered threatened at present.

Ceratozamia mixeorum Chemnick, Gregory & Salas-Morales 1998b

PLATES 65–67

The epithet for *Ceratozamia mixeorum* refers to the region of the Sierra Norte de Oaxaca, also known as the Sierra Mixes, and the Mixe Indians who inhabit it. Stems subterranean to shortly arborescent, smooth, medium brown, 0.3–1.3 m (1–4.3 ft) long, 14–18 cm (5.5–7.1 in) in diameter. In 20–25% of mature plants the stems branch underground, forming two to four branches of nearly equal length. Leaves usually 5–11, arching, glabrous, 1.5–2 m (4.9–6.6 ft) long, 51–70 cm (20–28 in) wide, flat, older plants holding as many as three crowns of leaves. Petiole 45–85 cm (18–34 in) long, 1–1.3 cm (0.4–0.5 in) in diameter, round, green, moderately armed with simple spines 3–5 mm (to 0.2 in) long. Leaflets in 25–36 pairs, linear lanceolate, often falcate, glossy dark green, lighter below than above, moderately leathery, flat to deflexed except for the basal three to five pairs, which are keeled, median leaflets 24–39 cm (9.4–15 in) long, 21–29 mm (0.8–1.1 in) wide, spaced 3–4 cm (1.2–1.6 in) apart, margin straight, slightly revolute, and turned upward. **Female cones** solitary, pendent, cylindrical, 23.5–30.5 cm (9.3–12 in) long, 12–15 cm (4.7–6 in) in diameter, yellowish green, apex truncate. Peduncle 12.5–23 cm (5–9.1 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, green with reddish brown tomentum. Sporophylls 24–28 mm (1–1.1 in) long. Sporophyll face 25–28 mm (1–1.1 in) high, 42–50 mm (1.6–2 in) wide, the horns bent downward, 5 mm (0.2 in) long, inserted 10 mm (0.4 in) apart, with a raised triangular process 3 mm long and wide directly above and between them. Sarcotesta white to cream when shed, turning brown after ripening. Sclerotesta ovoid, 25–32 mm (1–1.3 in) long, 18–20 mm (0.7–0.8 in) in diameter, tan, smooth. **Male cones** solitary, erect, long conical, 22–24 cm (8.7–9.4 in) long, 7–7.5 cm (2.8–3 in) in diameter, yellow-green. Peduncle 13.5–15 cm (5.3–6 in) long, 1.8–2 cm (0.7–0.8 in) in diameter, green but covered with reddish brown tomentum. Sporophyll face 7–8 mm (0.3 in) high, 14–15 mm (0.6 in) wide, yellow-green. **Habitat:** Cloud forest composed mainly of oaks and *Liquidambar* on steep east- and west-facing slopes at elevations of 1450–1900 m (4800–6200 ft), in rocky clay soil with outcrops of sedimentary rock, pH = 5. Rain falls throughout the year. **Distribution:** Mexico, southern Oaxaca state in the extreme eastern Sierra Norte de Oaxaca, also known as the Sierra Mixes, known only from two adjacent mountain peaks.

The first report I received of the *Ceratozamia* that was destined to become *C. mixeorum* was in 1973 from Glen Pollard, an American orchid collector in the city of Oaxaca, Mexico. I asked him if he had ever noticed any cycads during his orchid hunts, and he answered that he had seen some in the Sierra Mixes just 2 days prior to my visit. The country in that part of Oaxaca is high desert, so I was amazed when he showed me two seedlings of *Ceratozamia* he had collected there. He explained that the area in question was cloud forest at an elevation of more than 1500 m (4900 ft). On three different occasions over the next few years I tried to gain access to the habitat, but each time the road was impassable. Some years later I mentioned this location to Jeffrey Chemnick and Timothy Gregory, and they, too, tried to locate the plants without success. Finally, with the help of Silvia Salas-Morales, who had done field investigations in the area, they were able to locate and study this cycad population, leading to its description in 1998.

Ceratozamia mixeorum is apparently most closely related to *C. matudae* of southern Chiapas. This relationship is assumed because both species have extremely long peduncles that are not typical for the genus. There is also a complex of undescribed plants in Chiapas with long peduncles in need of further investigation. The plants from Chiapas, unlike *C. mixeorum,* all have narrow leaflets.

I am not aware of any specimens of *Ceratozamia mixeorum* in cultivation. This is no doubt the consequence of its remote habitat, and also the fact that it has not been known in botanical circles until more recently. *Ceratozamia mixeorum* will no doubt grow well in cultivation, as a number of similar species of *Ceratozamia* do. Success in the cultivation of *C. mixeorum* should be assured if plants are given temperate to tropical climates, soil that is moist and rich in humus, and overhead protection from the sun. Judging by the elevation at which *C. mixeorum* grows, it should be somewhat frost tolerant.

The conservation status of *Ceratozamia mixeorum* is difficult to assess. Only two populations, comprising approximately a thousand plants, are known, both suffering from clearing for planting coffee. Several nearby peaks in the surrounding mountains are likely to harbor additional populations of *C. mixeorum,* but this has not been determined. With the information that is available, *C. mixeorum* must be considered threatened.

Ceratozamia morettii Vázquez-Torres & Vovides 1998

PLATE 68

Ceratozamia morettii is named in honor of Aldo Moretti, a researcher at the Botanical Garden, University of Naples, Italy, in recognition of his contributions to cycad biology. **Stems** shortly arborescent, generally globose but sometimes attaining a length of 30 cm (12 in) and a diameter of 8 cm (3.2 in), generally bearing one to four branches armored with old cataphylls and leaf bases. Cataphylls triangular, about 26 mm (1 in) long and 20 mm (0.8 in) wide at the base. **Leaves** generally 1–7 per crown, rarely as many as 10, light green, spreading to prostrate, 1–1.4 m (3.3–4.6 ft) long, 40–65 cm (16–26 in) wide, emergent leaves lightly tomentose and circinate. Petiole terete to subterete, 45–60 cm (18–24 in) long, moderately armed with short stout spines. Leaflets in 12–25 pairs, papery, lanceolate, falcate, apex unevenly acuminate, veins parallel, translucent, pale yellow when viewed with transmitted light, median leaflets 25–35 cm (10–14 in) long, 27–48 mm (1.1–1.9 in) wide, and spaced about 5 cm (2 in) apart. **Female cones** solitary, erect to leaning, barrel shaped, 12–16 cm (4.7–6.3 in) long, 4.5–5 cm (1.8–2 in) in diameter, green when immature, turning brown at maturity. Peduncle terete, 5–7 cm (2–2.8 in) long, 1 cm (0.4 in) in diameter, dark brown tomentose. Sporophylls hexagonal, reddish brown, with two erect to curved horns. Sarcotesta at first yellowish white, turning light brown as it ripens. Sclerotesta irregularly ovoid, 15–18 mm (0.6–0.7 in) long, 12 mm (0.5 in) in diameter, light tan, smooth. **Male cones** solitary, erect, conical, elongate, 10–15 cm (4–6 in) long, 2.5–4 cm (1–1.6 in) in diameter, yellowish green. Peduncle terete, 5–7 cm (2–2.8 in) long, 1 cm (0.4 in) in diameter. Sporophylls wedge shaped, 10–12 mm (0.4–0.5 in) long, sporophyll face 8–9 mm (0.3–0.4 in) wide, with two prominent erect to curved horns 3–4 mm long. Sporangia in a single patch. **Habitat:** Primary cloud forest on humus-rich gray-yellow clay soil of volcanic origin, on steep 45–60° slopes or on vertical rocky walls of loose, weathered basalt, at elevations of 1200–1400 m (3900–4600 ft). The nearest climatological station has a recorded average rainfall of more than 1900 mm (75 in) annually and an average temperature of 17°C (63°F). **Distribution:** Mexico, Veracruz state, Sierra Madre Oriental north of Jalapa.

Ceratozamia morettii is doubtless allied to *C. latifolia,* and *C. microstrobila,* both of which are dwarf, branching cycads. The three species also share somewhat similar habitats, preferring steep, rocky, slopes shaded by dense forest. The only time I was able to investigate *C. morettii* in habitat was in 1986, a number of years before it was described. Its light green, pendent leaves and its preference for steep cliffs impressed me. The site I studied had numerous multiheaded specimens that grew just over the edge of a cliff 60 m (200 ft) high, making photography all but impossible.

Ceratozamia morettii exhibits distinctive translucent veins in its leaflets. Such veins also appear in other, but not all, populations of ceratozamias on the eastern coast of Mexico. The populations with yellowish translucent veins are generally much larger plants that fall into the *Ceratozamia robusta* complex. Two populations that come to mind are located near Santiago Tuxtla and Lago Catemaco, Veracruz, Mexico. Straight, upright leaves and petioles heavily armed with long, hooked spines typify the Santiago Tuxtla population. The Catemaco plants have more arching leaves, and fewer and shorter spines on the petiole.

Cultivation of *Ceratozamia morettii* is no more difficult than for other species of the genus. All ceratozamias make fine garden plants and display a high degree of cold tolerance. *Ceratozamia morettii* should make a fine pot plant because of its smaller size. Two specimens I have had in cultivation about 10 years have grown well and presented no problems.

The conservation status of *Ceratozamia morettii* at first appears to be secure, with thousands of plants in more or less inaccessible areas. New roads are being constructed into the habitat, however, and these will no doubt lead to farming and considerable habitat loss for the cycads.

Ceratozamia norstogii D. W. Stevenson 1982

PLATES 69, 70

Ceratozamia norstogii is named in honor of Knut Norstog, researcher of the Cycadales. **Stems** subterranean or shortly emergent, usually 12–130 cm (4.8–51 in) long, 13.7–22 cm (5.4–8.7 in) in diameter, rarely branched, and decumbent in older specimens. **Leaves** usually 6–8, sometimes as many as 15, erect, twisted through one to three revolutions, 1–1.3 m (3.3–4.3 ft) or 2.1–2.4 m (6.9–7.9 ft) long, 58–95 cm (23–37 in) wide, emergent leaves purplish brown, moderately gray tomentose, soon becoming glabrous. Petiole 11–38.5 cm (4.3–15 in) long, 6–7 mm (0.2–0.3 in) in diameter, moderately to densely armed with spines 3–5 mm (to 0.2 in) long. Leaflets in 33–65 pairs, 34–57 cm (13–22 in) long, 3–5 mm (to 0.2 in) wide, straight to subfalcate, channeled, margin entire and not revolute. **Female cones** solitary, erect, 20–37 cm (8–15 in) or about 53 cm (21 in) long, 8–10 cm (3.2–4 in) in diameter, olive green to brownish green, apex made of reduced sporophylls. Sporophyll face 1–2.5 cm (0.4–1 in) high, 3.5 cm (1.4 in) wide. Peduncle 6–10 cm (2.4–4 in) long, 8–19 mm (0.3–0.8 in) in diameter, densely tan tomentose. Sporophylls 42–55 mm (1.7–2.2 in) long. Sporophyll face 18–20 mm (0.7–0.8 in) high, 35–52 mm (1.4–2 in) wide, lightly tomentose except for the densely tan tomentose margins, the central horns 5–7 mm (0.2–0.3 in) long, about 5 mm (0.2 in) wide at their base, connected by a terminal facet 8–10 mm (0.3–0.4 in) long, 1–2 mm wide, lateral facets indistinct. Sarcotesta cream colored and lightly sprinkled with red-brown scales. Sclerotesta ovoid to globose, 21–25 mm (0.8–1 in) long, 16–21 mm (0.6– in) in diameter, tan, smooth, except for 6–11 indistinct grooves radiating from the micropyle. **Male cones** solitary, erect, long conical, 25–35 cm (10–14 in) long, 6.5–7 cm (2.6–2.8 in) in diameter, olive green to pale yellow, lightly tomentose, apex mucronate. Peduncle 5–6.5 cm (2–2.6 in) long, 2–2.3 cm (0.8–0.9 in) in diameter, densely brown tomentose. Sporophylls 18–20 mm (0.7–0.8 in) long, bicornate. Sporophyll face 7–11 mm (0.3–0.4 in) high, 12–15 mm (0.5–0.6 in) wide. Sporangia in a single patch. **Habitat:** Seasonally dry oak-pine woodland at elevations of 1050–1200 m (3450–3900 ft). **Distribution:** Mexico, northwestern corner of Chiapas state in the northern section of the Sierra Madre de Chiapas (Sierra de Soconusco), also reported from southern Oaxaca.

The existence of *Ceratozamia norstogii* has been known since the early 1900s when Carl Albert Purpus collected it at Finca Fénix in northwestern Chiapas, Mexico. The late Albert Wilson, an American plant collector who lived in Brownsville, Texas, first introduced it into the trade in the early 1960s. *Ceratozamia norstogii* was not available in any quantity until the 1980s when two major commercial collections were imported into the United States. This cycad is more of a collector's item than a landscape plant because of its unusual, rather than handsome, appearance. Its upright, wispy, plumelike leaves are difficult to see at distance, tending to blend into the background.

There are two forms of *Ceratozamia norstogii* in Chiapas. One is from near Rizo de Oro, the other from above Cintalapa. The main difference between the two forms is size, with the Rizo de Oro plants having leaves 1.3 m (4.3 ft) long and female cones 20 cm (8 in) long, the Cintalapa plants having leaves 2.1–2.4 m (6.9–7.9 ft) long and female cones 53.3 cm (21 in) long. These two forms do not overlap in distribution and may prove to represent two closely related species.

When Dennis W. Stevenson described *Ceratozamia norstogii,* the specimens cited comprised two species, *C. norstogii* and the more recently described *C. mirandae.* The two species are quite distinct and can be easily separated on the basis of their foliage. *Ceratozamia mirandae* has flat, arching leaves, and *C. norstogii* has erect, twisted or plumose leaves with narrower leaflets. The two species grow in the same general area of Chiapas but I know of no place where their populations overlap. The mixing of the cited specimens has caused the confusion surrounding the identity of *C. norstogii.*

Collected stems of *Ceratozamia norstogii* have proved to be difficult to reestablish, and many of the imported plants perished. Those that did become reestablished proved to be easily grown and reasonably frost tolerant. They require a bright, semishaded position in well-drained soil and some fertilization during the summer. This cycad is almost pest-free and will rarely have an infestation of mealybugs. It makes a superior pot plant because of its smaller size and upright leaves. Artificial propagation of *C. norstogii* is for some reason very difficult, and few of the seeds produced prove viable.

Ceratozamia norstogii, as stated by Miguel A. Pérez-Farrera (pers. comm.) is endangered. Studies of the species by Pérez-Farrera have disclosed two additional colonies, but the type locality has few remaining plants.

Ceratozamia robusta Miquel 1848

PLATES 71, 72

The epithet for *Ceratozamia robusta* is Latin for robust or vigorous, referring to the large size of this cycad. **Stems** arborescent, globular or cylindrical, usually unbranched or branched as a result of injury, erect or often decumbent, 1–2 m (3.3–6.6 ft) tall, 20–30 cm (8–12 in) in diameter, the exterior covered with the woody, often wrinkled remains of old leaf bases and cataphylls. **Leaves** usually 5–35 per crown, 2–4 m (6.6–13 ft) long, 60–90 cm (24–36 in) wide. Petiole 20–60 cm (8–24 in) long, 12–13 mm (0.5 in) in diameter, lightly to heavily armed with straight or curved spines 5–7 mm (0.2–0.3 in) long. Petiole base stipulate, swollen, and persistently hairy. Leaflets in 50–100 pairs, linear lanceolate to lanceolate, sometimes falcate, light green above, paler below, median leaflets 25–40 cm (10–16 in) long, 2.5–4 cm (1–1.6 in) wide, margin lightly to strongly revolute. **Female cones** solitary, at first upright, horizontal or pendent as the cone matures, 25–40 cm (10–16 in) long, 10–15 cm (4–6 in) in diameter, dark olive green, the surface covered with numerous small dark brown scales, especially toward the center of the sporophylls. Peduncle woolly, 6–7 cm (2.4–2.8 in) long, 2.5–3 cm (1–1.2 in) in diameter. Sporophylls with two stout and flattened horns. Sporophyll face 2–2.5 cm (0.8–1 in) high, 3–3.5 cm (1.2–1.4 in) wide. Sarcotesta white or light cream when seed is first shed, turning brown and soft as it ripens. Sclerotesta ovoid, somewhat three-sided, 2.5–3 cm (1–1.2 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, light tan, smooth. **Male cones** solitary, erect until the pollen is shed, then rapidly leaning or drooping, cylindrical or long conical, 31–40 cm (12–16 in) long, 5–7 cm (2–2.8 in) in diameter, olive green. Peduncle 55–70 mm (2.2–2.8 in) long, 25–28 mm (1–1.1 in) in diameter, densely brown tomentose. Sporophylls with two flattened horns 2–5 mm (to 0.2 in) long. Sporophyll face wedge shaped, 3–5 mm (to 0.2 in) high, 10–16 mm (0.4–0.6 in) wide. Sporangia in a single patch covering most of the underside the sporophyll. **Habitat:** Rain forest, usually in limestone areas on steep slopes or cliffs, at elevations of 150–775 m (490–2550 ft). Rainfall generally averages 2000 mm (79 in) annually, falling mainly in summer. Temperatures average 20–30°C (68–86°F) in summer, more than 20°C (68°F) in winter. **Distribution:** Mexico, in Chiapas, Oaxaca, Tabasco, and Veracruz states, also reported from Belize and Guatemala.

When Friedrich Anton Wilhelm Miquel (1848) described *Ceratozamia robusta,* the type locality was given only as Mexico. Dennis W. Stevenson and Sergio Sabato (1986) stated that after a search of the world's herbaria none of the original specimens of *C. robusta* could be located. In the absence of a type specimen they designated a neotype, *Stevenson 549A.* The new type, they felt, matched the original description. The plant they chose as the neotype was collected in the mountains behind Tuxtla Gutiérrez, Chiapas. I am not completely happy with this choice, as there was no botanical exploration being carried out in that area of Mexico in the early 1800s. I feel that one of the *robusta*-like ceratozamias closer to the old port of Veracruz would have been a better choice. In keeping with the neotype, all measurements given for *C. robusta* here are taken from the Chiapas population.

Ceratozamia robusta is the largest species of the genus. As this species is now defined, it ranges from southern Mexico to Belize and Guatemala. The plants within this area are exceedingly variable as to trunk size, length and width of leaves and leaflets, size and number of spines arming the petiole and rachis, and size and shape of cones. A number of these variants are distinctive enough to be chosen easily from a collection of mixed plants, and further investigation may prove some of these forms to be species. The largest and most vigorous of these forms is from the forests of Belize and Guatemala, producing relatively short, thick stems with leaves to 4 m (13 ft) long. Rapid growth is a mark of this group, and mature plants may be produced from seed in as few as 10 years.

All *Ceratozamia robusta* variants originate in dense, wet, semideciduous rain forests of moderate elevation and occur most commonly on steep hillsides and cliffs. They often lean or hang from their roots, a result of the steep nature of the habitat and the loose organic soil in which they grow. Debris from the sheltering forest collects in the crowns of these plants, making them appear to have stems of large diameter. Removing this debris and old leafstalks discloses the actual size to be about half its original appearance. This forest habitat provides several conditions in which *C. robusta* can flourish. It protects the cycads from wind damage, provides necessary shade, and produces the moist, humus-rich soil they prefer.

In cultivation, *Ceratozamia robusta* will form large clumps or specimens. This cycad will flourish in low-light situations if given an open, moist soil and occasional applications of fertilizer during the growing season. Because of its large size and generally very spiny stems, *C. robusta* must be given sufficient space to develop properly. Growth is generally good even when planted in bright or sunny areas. Closer to the coast, or in subtropical, humid environments, *C. robusta* can tolerate full sun, but the foliage may yellow somewhat. Generally, *C. robusta* has good cold tolerance and will not be damaged at a few degrees below freezing. In areas that experience frost it is best to plant *C. robusta* where it has some overhead protection. Its size makes *C. robusta* a good choice in large landscapes, especially if low-light conditions are a problem.

The conservation status of *Ceratozamia robusta* is difficult to define. If we accept all the forms now included in the concept of the species, it is not in imminent danger. On the other hand, some of the forms have a very limited distribution and are in danger of extinction. Until more recently, *C. robusta* was considered by some taxonomists to be a variant of *C. mexicana.* As additional study is given to the genus, especially this species, other forms, perhaps to be recognized as different species, will no doubt emerge.

Ceratozamia sabatoi Vovides, Vázquez-Torres, Schutzman & Iglesias 1993

PLATES 73, 74

Ceratozamia sabatoi is named in honor of Sergio Sabato (1941–1991), Italian botanist and professor at the University of Naples who was well known for cycad research in the New World Tropics. **Stems** partly or entirely subterranean, globose or cylindrical in very old specimens, to 25 cm (10 in) long, 7.5–17.5 cm (3–6.9 in) in diameter, often producing numerous basal offsets. Leaf bases persistent, and the stem dark brown with a rough surface. **Leaves** two to six, to 80 cm (32 in) long and 52 cm (20 in) wide. Petiole 15–25 cm (6–10 in) long, 3–5 mm (to 0.2 in) in diameter, unarmed to lightly armed with short, stout spines, the expanded base persistently tomentose. Leaflets in 12–136 pairs, light to dark green, lanceolate, glabrous, 9–29 cm (3.5–11.4 in) long, 7–24 mm (0.3–0.9 in) wide, attached to the rachis every 2–5 mm (to 0.2 in), apex pungent, margin entire and lightly revolute. **Female cones** solitary, cylindrical to barrel shaped, 6–12 cm (2.4–4.7 in) long, 34–56 mm (1.3–2.2 in) in diameter, slightly tapering toward the apex, light blue-green when immature. Peduncle tomentose, 2–10 cm (0.8–4 in) long, 6–13 mm (0.2–0.5 in) in diameter. Sporophylls 17–26 mm

(0.7–1 in) long. Sporophyll face hexagonal, 10–12 mm (0.4–0.5 in) high, 11–28 mm (0.4–1.1 in) wide, bicornate, the horns either straight or bent slightly upward, with reddish tomentum near their base. Sarcotesta creamy white before ripening, becoming blue-green to light brown when ripe. Sclerotesta ovoid, 13–19 mm (0.5–0.8 in) long, 11–14 mm (0.4–0.6 in) in diameter, light tan, the surface smooth except for 8–10 visible ridges radiating from the micropyle. **Male cones** solitary, long conical, 6.5–23 cm (2.6–9.1 in) long, 1.9–3 cm (0.8–1.2 in) in diameter, green. Peduncle 1.5–11 cm (0.6–4.3 in) long, 5–10 mm (0.2–0.4 in) in diameter, tomentose. Sporophyll wedge shaped, bicornate, the horns bent downward, 9–14 mm (0.4–0.6 in) long. Sporophyll face about 3 mm high, 4–7 mm (to 0.3 in) wide. Sporangia in a single somewhat heart-shaped patch covering the entire underside of the sporophyll. **Habitat:** Pine-oak woodland or mixed oak forest at elevations of 1400–1500 m (4600–4900 ft), on steep slopes under cover of trees, in humus-rich clay soil usually over limestone. The habitat is consistently damp to wet from low clouds or rain. **Distribution:** Mexico, Hidalgo and Querétaro states.

Ceratozamia sabatoi is most closely related to two other dwarf ceratozamias, *C. kuesteriana* from Tamaulipas, Mexico, and *C. microstrobila* from San Luis Potosí. The leaflet width of *C. sabatoi* is midway between that of the two, with *C. kuesteriana* longer and narrower, *C. microstrobila* shorter and broader. These two species are found some distance to the north of *C. sabatoi,* and no overlapping of the populations is known to occur.

In cultivation, *Ceratozamia sabatoi* is not difficult to maintain. As one would expect from a dwarf species, growth is not rapid. One to five leaves are produced annually, the number depending on the size of the stem. New growth usually displays a somewhat glaucous cast to the leaflets, gradually disappearing with age. I have had difficulty in getting this species to cone when potted, but planted in the ground the majority of plants coned the following year. Once *C. sabatoi* reaches maturity, profuse suckering takes place around the stem base. Cones are produced in the area of Los Angeles, California, in April and May, becoming receptive in June.

Ceratozamia sabatoi is a very interesting species that could be used effectively in the landscape where a small, low-growing, and shade-loving cycad is desired. As with most ceratozamias, *C. sabatoi* is frost tolerant, especially when protected by overhanging branches.

Ceratozamia sabatoi should be considered threatened. Several populations are known to be fairly extensive, and at present, the habitat is not under pressure for clearing. There is a hydroelectric project at Zimapán, Hidalgo, however, that will submerge a large area of the known habitat.

Ceratozamia whitelockiana Chemnick & Gregory 1995

PLATES 75–78

The epithet for *Ceratozamia whitelockiana* recognizes Loran M. Whitelock for his contributions to cycad study. **Stems** mostly subterranean, irregularly cylindrical, 20–30 cm (8–12 in) long, 12–18 cm (4.7–7.1 in) in diameter, covered with an armor of brownish red, rough, irregular, and persistent leaf and cataphyll bases. Cataphylls wrinkled, stipulate, triangular, densely white hairy at the crown, irregularly arranged on the lower portions of the stem, about 5 cm (2 in) long and wide. **Leaves** usually two to four, upright, apex arching, 2–2.5 m (6.6–8.2 ft) long, 0.6–1 m (2–3.3 ft) wide, the basal 25–30% of the leaf keeled, becoming flat toward the apex, emergent leaves pea green, glaucous. Petiole 1–1.3 m (3.3–4.3 ft) long, 7–8 mm (0.3 in) in diameter, round, sparsely armed with spines 1–3 mm long. Leaflets in 30–40 pairs spaced 2.5–5 cm (1–2 in) apart, opposite to subopposite, linear lanceolate to falcate, thin textured, gradually and unequally drawn out, gradually reduced in length toward the apex, median leaflets 30–50 cm (12–20 in) long, 3–3.8 cm (1.2–1.5 in) wide, margin entire, lightly revolute, and turned upward. **Female cones** solitary, cylindrical to ovoid, 14–18 cm (5.5–7.1 in) long, 7.5–10 cm (3–4 in) in diameter, with a large, solid apiculum, the apiculate cap 1.5–3 cm (0.6–1.2 in) long, 3–4 cm (1.2–1.6 in) in diameter. Peduncle 3–3.8 cm (1.2–1.5 in) long, 1.8–2 cm (0.7–0.8 in) in diameter. Sporophylls 2.5–3 cm (1–1.2 in) long. Sporophyll face 17–23 mm (0.7–0.9 in) high, 35–50 mm (1.4–2 in) wide, the center moderately glabrous, the rolled margins gray tomentose, the horns divergent to either side of the sporophyll and to 1 cm (0.4 in) long, only slightly raised above the face and joined by a wrinkled raised ridge. Sarcotesta white to cream, rapidly turning brown as it ripens. Sclerotesta irregularly ovoid, 24–26 mm (0.9–1 in) long, 18–20 mm (0.7–0.8 in) in diameter, tan, the surface smooth except for eight or nine indistinct longitudinal ridges. **Male cones** solitary, long conical, 26–28 cm (10–11 in) long, 28 mm (1.1 in) in diameter, olive green, apex mucronate. Peduncle 20–30 mm (0.8–1.2 in) long, 11–15 mm (0.4–0.6 in) in diameter, densely tomentose to woolly. Sporophylls bicornate. Sporophyll face 3–5 mm (to 0.2 in) high, 8–9 mm (0.3–0.4 in) wide. **Habitat:** Heavily shaded east- and west-facing steep slopes in remnants of montane tropical forest at elevations of 340–970 m (1100–3200 ft) but more commonly to 600 m (2000 ft). Rainfall averages 1500–2000 mm (59–79 in) annually, the heaviest precipitation in summer. Temperatures average 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. Low clouds and fog are common and help maintain a relatively high humidity and soil moisture. **Distribution:** Mexico, Oaxaca state, restricted almost entirely to the drainage of the Río Valle Nacional.

Ceratozamia whitelockiana was first recognized as a possibly unknown taxon in the mid-1970s and was referred to as *C.* "Valle Nacional." Very few specimens have ever been collected because of its remote habitat, which is difficult to reach, and the widely scattered plants in the colony. The cycad is rarely seen in collections and has been generally unknown to collectors and scientists. The few times it has been mentioned in floristic surveys, *C. whitelockiana* has been misidentified as *C. robusta.* Actually, *C. whitelockiana* is most closely related to the *C. euryphyllidia–C. miqueliana* complex (see the remarks under *C. euryphyllidia*) and produces the same glaucous emergent leaves so notable in those species. *Ceratozamia whitelockiana* produces fewer leaves that are erect, longer, and with a petiole usually half of the total length of the leaf. Its leaflets are much longer and narrower, gradually and only slightly unequally acuminate at their apex, as opposed to the shorter, broader, and abruptly unequally acuminate leaflet apex of *C. euryphyllidia* and *C. miqueliana.* The nearest known occurrence of *C. miqueliana* to *C. whitelockiana* is approximately 180 km (110 miles) away.

Dispersal of *Ceratozamia* seeds, because of the steep hillsides on which the plants usually grow, is generally thought to be by gravity. Jeffrey Chemnick (pers. comm.) has brought to my attention that a bird, the great curassow (*Crax rubra*) is a dispersal agent for the seed of *C. whitelockiana.* A coffee farmer living in the *C. whitelockiana* habitat had shot a great curassow, a large turkey-like bird, and while cleaning it discovered several seeds of *C. whitelockiana* in its craw. These birds, after swallowing the seeds, would regurgitate them at another locality, cleaned of their sarcotestas. This is the first documented report of which I am aware that links seed dispersal of *Ceratozamia* to birds. Additional research may show that the great curassow is involved with the dispersal of other species of *Ceratozamia* as well.

In cultivation, *Ceratozamia whitelockiana* grows well with a minimum of care if given a shady, damp location. It is less frost tolerant than the majority of ceratozamias and should be given overhead protection and a warm position for best results. The leaves are upright at first, then somewhat spreading. Grown as a garden or greenhouse plant, this cycad cones frequently and viable seed can be produced by hand pollination. Seedling leaves of *C. whitelockiana* look very much like those of *C. miqueliana,* and it would be almost impossible to separate mixed seedlings until mature leaves are produced.

The conservation status of *Ceratozamia whitelockiana* is not good. Its habitat is being reduced by slash and burn agriculture, and it is being replaced by coffee and bananas. Studies by Jeffrey Chemnick and Timothy Gregory revealed roughly 50% reduction in number of individuals in the study area in a period of about 15 years. The clearing operations in more recent years are proceeding at an ever increasing rate. *Ceratozamia whitelockiana* must be considered extremely endangered.

Ceratozamia zaragozae Medellin-Leal 1963

PLATES 79–81

Ceratozamia zaragozae is named in honor of General Ignacio Zaragoza (1829–1862), a hero of the Mexican Revolution. **Stems** unbranched but with numerous basal offsets, somewhat subterranean, 9–40 cm (3.5–16 in) long, 9–11 cm (3.5–4.3 in) in diameter, the surface generally smooth and light brown. **Leaves** usually 3–5, rarely as many as 13 in mature plants, at first erect, then spreading, plumelike, stipulate, 0.2–1.5 m (0.7–4.9 ft) long, 16–43 cm (6.3–17 in) wide, emergent leaves lightly white hairy, glabrous when mature, leaflets green with a somewhat brownish rachis. Petiole semiterete, 15–43 cm (6–17 in) long, 3–6 mm (to 0.2 in) in diameter, unarmed. Rachis erect and curved inward, usually twisted through one revolution or more. Leaflets linear lanceolate, straight or slightly falcate, 5–28 cm (2–11 in) long, 4–6 mm (0.2 in) wide, with 4–10 veins, and inserted 8–24 mm (0.3–0.9 in) apart. **Female cones** solitary, subcylindrical, 8–12 cm (3.2–4.7 in) long, 6–7 cm (2.4–2.8 in) in diameter, light olive green, apex mucronate. Peduncle 9–10 cm (3.5–4 in) long, 1–1.2 cm (0.4–0.5 in) in diameter, densely tomentose. Sporophyll face subhexagonal, 20–25 mm (0.8–1 in) high, 22–40 mm (0.9–1.6 in) wide, glabrous, facets not well defined, the center with two very small horns spaced about 1 cm (0.4 in) apart, the separation somewhat wrinkled, a pronounced horizontal ridge extending from the horns to each side. Sarcotesta white when mature, turning brown shortly after seed is shed. Sclerotesta subglobular, 16–21 mm (0.6–0.8 in) long, 15–17 mm (0.6–0.7 in) in diameter, light tan, smooth. Chalaza prominently elevated and closely set with pits and grooves. **Male cones** solitary, elongate subcylindrical to subconical, 10–20 cm (4–8 in) long, 2–3 cm (0.8–1.2 in) in diameter, olive green to brownish green, apex acute, mucronate. Peduncle 9–14 cm (3.5–5.5 in) long, 6–10 mm (0.2–0.4 in) in diameter, heavily tomentose. Sporophylls 8–11 mm (0.3–0.4 in) long, the two horns about 2 mm long, bent downward at the apex. Sporophyll face 2–3 mm high, 3–6 mm (to 0.2 in) wide. Sporangia in a single regularly shaped patch that continues up the sides of the sporophyll. **Habitat:** Dry pine-oak woodland in rhyolitic soils, associated with cacti and other plants adapted to dry conditions, at elevations of about 1800 m (5900 ft). **Distribution:** Mexico, San Luis Potosí state, Sierra de la Equiteria about 30 km (18 miles) southwest of Río Verde.

On July 22, 1962, a group of botanists (Fernando Medellin-Leal, Elwood Molseed, and Myron Kimnach) collected a *Ceratozamia* in the vicinity of Río Verde, San Luis Potosí, Mexico. The plants were growing in very dry pine-oak woodland and were remarkable in having consistent spiral twisting of the leaves, an unarmed petiole, and extremely small horns on the megasporophylls. Medellin-Leal published the description of *C. zaragozae* in April 1963.

Ceratozamia zaragozae is unique in the genus as it is the only species known to inhabit a desert habitat. Other ceratozamias are plants of moist pine-oak woodland to rain forest. The distinctive leaves are spirally twisted through one revolution or more, held upright, and curved inward to form a bowl-shaped crown. These traits, combined with the long, narrow leaflets and the retention of old leaves, give the impression of a tumbleweed when a plant is seen at a distance.

The only other species that could be confused with *Ceratozamia zaragozae* is *C. norstogii* of northern Chiapas. It also has spirally twisted leaves but is much larger and heavily armed with spines on both the petiole and rachis. The two species can also be separated by differences in the female cones. Those of *C. zaragozae* are small with extremely small horns on the sporophyll face whereas those of *C. norstogii* are much larger with prominent, well-developed horns on the sporophyll face.

Ceratozamia zaragozae does not present any problems in cultivation. As with most other cycads, good drainage is essential and feeding beneficial. Cone production is more frequent in cultivated plants, and viable seed can be set using one of the techniques outlined in Chapter 5.

The conservation status of *Ceratozamia zaragozae* is precarious because large areas of its range have been so heavily collected that it has been all but eradicated from some locations. It must be classed as endangered, and strong protective measures should be taken to ensure its survival in the wild. In conjunction with habitat conservation, artificial propagation should be promoted to increase the number of plants in cultivation.

Ceratozamia zoquorum Pérez-Farrera, Vovides & Iglesias 2001

PLATES 82, 83

Ceratozamia zoquorum is named for the Zoque Indians who inhabit the area of Chiapas where the cycad grows. **Stems** solitary, rarely branched but sometimes suckering from the base, 10–48 cm (4–19 in) long, 13–18 cm (5.1–7.1 in) in diameter, covered with dark brown to reddish brown cataphylls and leaf bases. Cataphylls triangular, stipulate, densely gray tomentose at their base, 3.5–5.5 cm (1.4–2.2 in) long, 2.5–3.5 cm (1–1.4 in) wide. **Leaves** in mature plants one to five, ascending to decumbent, 0.8–2.7 m (2.6–9 ft) long, 42–75 cm (17–30 in) wide, flat in cross section, emergent leaves lightly covered with white hairs 3–5 mm long and with a brownish pink rachis and green leaflets with a strong blue-gray waxy bloom that is very persistent. Petiole terete, 20–124 cm (8–49 in) long, glaucous, unarmed or with a few widely spaced short prickles, older plants often unarmed. Leaflets in 5–16 pairs, opposite to alternate, oblong to oblanceolate, the apex unequally acuminate, very leathery, 23–38.5 cm (9.1–15 in) long, 3.2–6.5 cm (1.3–2.6 in) wide, glaucous above, light green below, with 27–42 clearly visible veins, margin entire, lightly revolute. **Female cones** solitary, cylindrical to barrel shaped, decumbent, 22–26 cm (8.7–10 in) long, 9.5–9.8 cm (3.7–3.8 in) in diameter, dark green at emergence, olive green at maturity. Peduncle tomentose, 6–7 cm (2.4–2.8 in) long, 1.9–2 cm (0.8 in) in diameter. Sporophylls peltate, 1.5–2.3 cm (0.6–0.9 in) long. Sporophyll face hexagonal, bicornate, 2.4–2.8 cm (1–1.1 in) wide, 1–1.2 cm (0.4–0.5 in) high, with a reddish brown tomentum surrounding the horns. Sarcotesta white when immature, creamy yellow at maturity. Sclerotesta 2.1–2.2 cm (0.8–0.9 in) long, 1.6–1.7 cm (0.6–0.7 in) in diameter, light tan, smooth, with visible lines radiating from the micropyle. **Male cones** solitary, erect, light green at emergence, light yellow to creamy when mature, 11.2–29 cm (4.4–11 in) long, 2.9–4.3 cm (1.1–1.7 in) in diameter. Peduncle light brown tomentose at emergence, brownish red tomentose when mature, 4–10.5 cm (1.6–4.1 in) long, 1.1–1.8 cm (0.4–0.7 in) in diameter. Sporophylls wedge shaped, 1.2–1.4 cm (0.5 in) long. Sporophyll face bicornate, 7–9 mm (0.3–0.4 in) wide, with red tomentum surrounding the horns. Sporangia in a single patch covering 50–75% of the lower surface. Habitat: Understory of evergreen tropical rainforest at elevations of 520–1200 m (1700–3900 ft), on cliffs or limestone outcrops on steep slopes with grades of 70% or more. Distribution: Mexico, northwestern section of Chiapas state.

Ceratozamia zoquorum is part of the *C. miqueliana* complex. It exhibits the same glaucous green leaves with broad, unequally attenuate leaflets. *Ceratozamia zoquorum* can be easily separated from *C. miqueliana* by its leathery rather than papery leaflets, its much more glaucous leaves, and its decumbent rather than erect female cones. It appears to be closely related to a *Ceratozamia* from Tabasco (see the remarks under *C. euryphyllidia*). The Tabasco plant is smaller, has fewer leaves and generally much shorter, broader leaflets but shares the same habitat preference for growing on limestone cliffs under evergreen tropical rainforest. The Tabasco plant is under investigation with the view of describing it as a species.

Not a great deal is known in regard to the cultivation requirements of *Ceratozamia zoquorum.* It will probably require the same conditions as *C. miqueliana,* which is a shaded growing area protected from hard freezes and wind. I have not seen this plant personally, but photographs indicate that it is a truly beautiful *Ceratozamia* with its arching leaves, broad and leathery leaflets, and very glaucous green coloration. In fact, *C. zoquorum* has the grayest leaves of any *Ceratozamia.*

The information available indicates that *Ceratozamia zoquorum* is limited to a single population. The habitat of *C. zoquorum* is located in one of the most developed regions in Mexico. A great deal of the surrounding area has been transformed into cattle pastures and full-sun coffee plantations, which has resulted in the loss of a large portion of the original primary vegetation. It has been suggested that *C. zoquorum* may eventually become extinct if habitat destruction continues at its present rate. Efforts have been made for the conservation of *C. zoquorum* by bringing it into cultivation at the Jardín Botánico Francisco Javier Clavijero at Jalapa, Veracruz, and at UNICACH (Universidad de Ciencias y Artes de Chiapas) at Tuxtla Gutiérrez, Chiapas.

Chigua D. W. Stevenson 1990

The name of the genus *Chigua* is the common name used by some Central and South American Indians for zamias. Two species (type, *C. restrepoi*). Chromosome number $2n = 16$. *Chigua* together with most of the other cycad genera constitute the family Zamiaceae.

Stems subterranean, tuberous, each plant with a single tuber, rarely branched.

Leaves usually two to four, 1–2 m (3.3–6.6 ft) long, distinguished by a prominent midrib in each leaflet.

Female cones distinguished by an extremely long peduncle that merges gradually with the base of the cone, and hexagonal sporophylls with a bump at each angle of the sporophyll face, these the characteristics of *Chigua restrepoi.*

Male cones similar to the female cones but with a shorter peduncle and flat sporophyll faces.

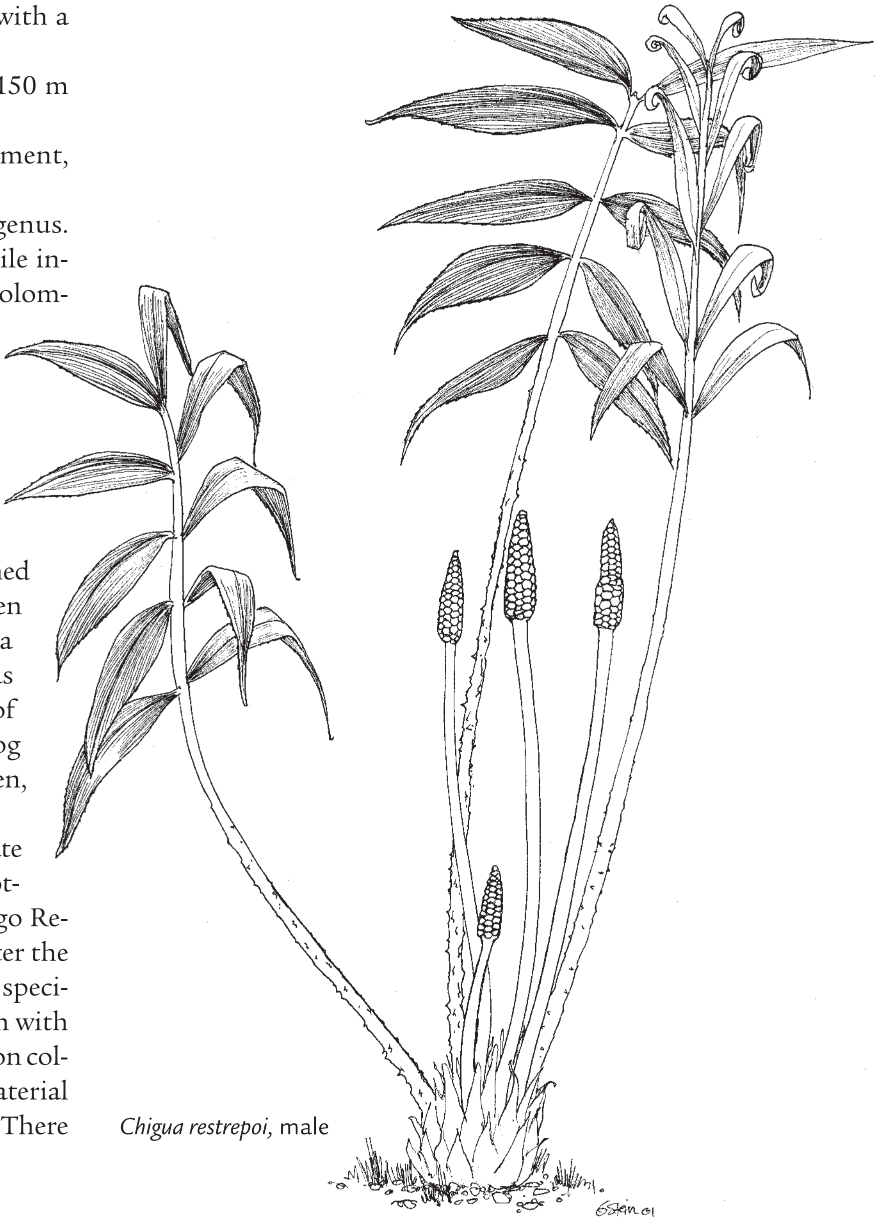
Habitat: Wet rain forest at elevations of 75–150 m (250–490 ft).

Distribution: Colombia, Antioquia department, near the upper reaches of the Río Sinu.

Chigua, described in 1990, is the latest cycad genus. Francis Pennell discovered the cycad in 1918 while involved in the botanical exploration of northern Colombia. Pennell collected material of a small cycad that at the time was assigned to *Zamia.* The sterile collection consisted of a single leaf and a section of unbranched tuber. The significance of this specimen was not recognized until early in the 1980s, when Sergio Sabato was researching the vouchers of the Gray Herbarium, Harvard University, in order to typify all validly published names in *Zamia.* While studying Pennell's specimen he noted that each leaflet possessed a midrib, a characteristic unknown in *Zamia.* This fact was brought to the attention of Dennis W. Stevenson of the New York Botanical Garden, and Knut Norstog and John Popenoe of the Fairchild Tropical Garden, Miami, Florida.

Subsequently, two expeditions were made to locate this unique plant. In July 1986 three Colombian botanists (Rodrigo Bernal, Gloria Galeano, and Diego Restrepo) were successful in locating specimens. Later the same year, Ian Turner of Zimbabwe also collected specimens of the original plant and an additional form with long, narrow leaflets. In 1987 Norstog and Stevenson collected material of both species, which provided material for the description of the new genus in early 1990. There has been some disagreement among members of the botanical community as to whether *Chigua* is distinct or should be included in *Zamia.* The dissenters argue that the mere formation of leaflet veins into a midrib is not sufficiently unique for the recognition of a new genus. More recently, electrophoretic analysis of its enzymes shows *Chigua* to be well within the limits of variability shown in the genus *Zamia.* Time and additional research will no doubt determine whether *Chigua* is in fact distinct or a divergent form of *Zamia.* The choice of name is unfortunate and has created confusion between the genus *Chigua* and *Zamia chigua,* both from Colombia.

More recently, questions have been raised in regard to the existence of two species in the genus. Consideration



Chigua restrepoi, male

has been given to the idea that there is only one very variable species. The absence of cone material of *Chigua bernalii* makes it difficult to address this question properly. I have seen specimens collected from a single locality, displaying considerable leaflet variation, the extremes of which could reasonably be assigned either to *C. bernalii* or *C. restrepoi.* Obviously, additional fieldwork is necessary to prove, or disprove, the existence of two species.

Chigua is in critical danger of extinction because of the construction of a dam across the Río Sinu at Urra. The lake formed by this dam will submerge the entire habitat of *Chigua.* It is hoped that rescue operations will be initiated to prevent the extinction of the two species if none of the habitat can be saved. Both species of *Chigua* are listed in Appendix I of CITES.

Chigua bernalii D. W. Stevenson 1990

PLATE 84

Chigua bernalii is named in honor of Rodrigo Bernal (b. 1959), Colombian botanist who discovered this cycad in 1986. **Stems** subterranean, tuberous, elliptical, 30 cm (12 in) long, 7.5–10 cm (3–4 in) in diameter. Cataphylls pubescent, triangular, stipulate, 3–5 cm (1.2–2 in) long, 1–2 cm (0.4–0.8 in) wide. **Leaves** usually two or three, upright, glabrous, stipulate, 1–1.4 m (3.3–4.6 ft) long, 60–70 cm (24–28 in) wide. Petiole 12–17 cm (4.7–6.7 in) long and armed with small prickles that tend to continue up the rachis about half its length. Leaflets in 30–55 pairs, linear to linear lanceolate, papery, displaying a prominent midrib, median leaflets 30–35 cm (12–14 in) long, 1–1.5 cm (0.4–0.6 in) wide, margin flat, undulate, with well-defined teeth. **Cones** not described. **Habitat:** Wet rain forest at elevations of 75–150 m (250–490 ft). **Distribution:** Colombia, central Córdoba department near the Río Sinu.

Few specimens of *Chigua bernalii* are in cultivation. Neither male nor female cones have been found in wild plants or produced in cultivation. Until cone specimens are obtained, the description of this species remains incomplete. The habitat of this cycad is in an area of Colombia with major drug activity, making field investigations difficult and dangerous.

Chigua bernalii can easily be separated from *C. restrepoi* by its long, narrow leaflets and greater number of leaflet pairs, 30–55 pairs in *C. bernalii* compared to 20–30 pairs in *C. restrepoi.* These characteristics are maintained in cultivation, so they cannot be attributed to variations caused by growing conditions in the habitat. Cultivation of *C. bernalii* does not seem to be a problem since the plants grow well if given the same conditions required by tropical zamias.

The range of *Chigua bernalii* in its habitat is not known in much detail. Additional fieldwork will be necessary to provide answers to questions regarding its distribution. *Chigua bernalii* must be considered extremely endangered as a result of the dam being built across the Río Sinu at Urra, Córdoba.

Chigua restrepoi D. W. Stevenson 1990

PAGE 77, PLATES 85, 86

Chigua restrepoi is named in honor of Padre Sergio Restrepo (d. 1989), Colombian botanist who rediscovered this cycad. **Stems** subterranean, ellipsoid, 25–40 cm (10–16 in) long, 7.5–15 cm (3–6 in) in diameter. Cataphylls pubescent, triangular, stipulate, 3–5 cm (1.2–2 in) long, 1–2 cm (0.4–0.8 in) wide. **Leaves** usually two or three, 1.2–1.8 m (3.9–5.9 ft) long, 45–50 cm (18–20 in) wide. Petiole subterete, 50–60 cm (20–24 in) long, armed with scattered spines, base stipulate. Rachis semiterete, with scattered spines on its lower side. Leaflets in 20–30 pairs, lanceolate, opposite to alternate, papery, with a prominent midrib, median leaflets 15–25 cm (6–10 in) long, 3–5 cm (1.2–2 in) wide, margin flat, with well-defined teeth. **Female cones** solitary, cylindrical, 14–15 cm (5.5–6 in) long, 5 cm (2 in) in diameter, the exterior densely covered with reddish brown tomentum. Peduncle 25–30 cm (10–12 in) long, 1.5 cm (0.6 in) in diameter, glabrous. Sporophyll face hexagonal with a conspicuous bump at each angle of the hexagon, about 20 mm (0.8 in) high and 26 mm (1 in) wide. Sarcotesta red when ripe. Sclerotesta ovoid, smooth. **Male cones** generally three or four, sometimes as few as one or two, long conical, 5–10 cm (2–4 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, covered with reddish brown tomentum. Peduncle 15–21 cm (6–8 in) long, 4–6 mm (to 0.2 in) in diameter, lightly tomentose. Sporophylls hexagonal. Sporophyll face more or less flat, 3–6 mm (to 0.2 in) high, 15 mm (0.6 in) wide. **Habitat:** Rain forest and savanna at elevations of 75–150 m (250–490 ft). **Distribution:** Colombia, central eastern Córdoba department along the Río Sinu.

Not much is known about the requirements of *Chigua restrepoi* in cultivation, nor are many specimens in collections. Plants are in cultivation at the Fairchild Tropical Garden, Miami, Florida, the New York Botanical Garden, in Naples, Italy, and at the private garden of Ian Turner, Harare, Zimbabwe. Judging from its habitat, this cycad would be expected to do best in a hot, humid environment. One of the plants at the Fairchild Tropical Garden suffered the loss of its crown in a cold spell during the winter of 1989–1990. The plant was not killed and as of August 1990 was forming a new bud. It appears that this cycad will not tolerate temperatures much below 7°C (45°F).

Little is known of the range of *Chigua restrepoi.* Judging from available information, *C. restrepoi* does not appear to be common. *Chigua restrepoi* is a prime candidate for artificial propagation, and it is hoped that viable seed may be produced from the cultivated plants and distributed. *Chigua restrepoi* must be considered extremely endangered as a result of the damming of the Río Sinu at Urra, Córdoba, Colombia.

Cycas Linnaeus 1753

Todda-pana Adanson 1763
Epicycas de Laubenfels in de Laubenfels & Adema 1998

The name *Cycas* is from *kykas,* Greek for palm, referring to the palmlike growth habit. Ninety-one species (type, *C. circinalis*) with the possibility of many more as the genus receives additional fieldwork and taxonomic study. Chromosome numbers 2*n* = 22, 24. *Cycas* is the sole genus of the family Cycadaceae. Four sections have been recognized: *Asiorientales,* ovules tomentose, *Stangerioides*, microsporophylls soft and lacking an apical spine, *Indosinenses*, megasporophylls pectinate, and *Cycas*, megasporophylls entire or toothed but not deeply pectinate.

Stems variable, from dwarf or subterranean to those of treelike proportions with many branches, 9.2 m (30 ft) or more in height and with bases 1–1.5 m (3.3–4.9 ft) in diameter. *Cycas* comprises a large number of species spread over a large geographic area. As one might expect of such a widespread genus, habitats of the species vary from temperate to tropical, and from wet to dry. This variation has led to numerous adaptations of growth habit, especially in the stem. In many of the tropical species the usually persistent leaf bases are soon shed to form a smooth, skinlike surface. In drier or fire-prone areas the stem surface often cracks and fissures to form a hard, treelike bark, losing all remnants of the armor of old leaf bases. In some species the stems exhibit unusual prominent raised rings, and in others the bases are swollen into a broad, usually subterranean base.

Leaves of most *Cycas* species quite similar, unlike the wide variation shown in some cycad genera such as *Encephalartos* and *Zamia. Cycas* has a unique pattern of leaflet unfolding in that the leaflets are circinate, or coiled, at emergence. There is of course variation in length and width of both leaves and leaflets, and in the shape of the leaflets, such as straight, falcate, and so forth. Leaflet insertion into the rachis is also variable, and leaves may be flat (*C. basaltica*) or keeled to such a degree that the leaflets almost touch those from the opposite side of the leaf (*C. cairnsiana*). The angle of insertion of the leaflets into the rachis also varies. Leaflets may be at right angles to the rachis (*C. basaltica*) or angled forward about 45° (*C. revoluta*). Color ranges from dark green (*C. taitungensis*) to silver gray (*C. pruinosa*) with many variations in between. Some species have leaves that are heavily and persistently tomentose (*C. calcicola*).

Cycas chamberlainii

Cycas leaflets have a distinct midrib, which easily separates them from all other cycad genera with the possible exceptions of *Chigua* and *Stangeria.* In *Chigua* the midrib is not distinct but is rather a buildup and thickening of the veins at midleaflet. In *Stangeria* the leaflet veins branch dichotomously as opposed to the parallel veins of *Cycas.* Also, the margins of the leaflets in *Chigua* and *Stangeria* are serrate rather than entire as in *Cycas.* Leaflets are simple and lanceolate in all but four species of *Cycas*: *C. bifida*, *C. debaoensis, C. micholitzii,* and *C. multipinnata.* These species have the remarkable feature of dichotomous branching of the leaflets. Leaflets in adult specimens of *C. bifida* may branch as many as three times, giving the overall outline of the leaflet a fanlike appearance. *Cycas debaoensis* and *C. multipinnata* are unique in having bipinnate leaves. Leaflet width varies from species to species. Species with very narrow leaflets usually have revolute margins whereas those with broad leaflets normally have flat margins.

Female cones easily distinguishing *Cycas* from all other genera of cycads because it is the only genus that does not form a conelike structure encasing the seeds. The individual female sporophylls are more like modified leaves and carry as many as seven pairs of seeds attached along the margin. Each sporophyll ends in a spoon-shaped lamina, which may or may not be armed with spines along the margin. In the study of *Cycas* species and their relationships, the morphology of the female sporophyll is one of the most useful diagnostic features.

The female cones of *Cycas* may be divided into two types. The first type, found mainly in Asia, India, and the Philippines, has the sporophylls upright and tightly pressed together, forming a compact dome in the center of the leaf crown as in *C. revoluta.* This "closed cone" remains in place until a new set of leaves forces its way through its center. Even as the new leaves force the sporophylls outward and downward, the sporophylls persist in their compact alignment. The second type, found mainly in the South Pacific, Australia, the Indian Ocean, Madagascar, and Africa, has long, often pendent sporophylls. From their inception the sporophylls tend to be open and loose in arrangement in this "open cone."

In the open cone the seeds are always exposed, in contrast to being tightly held within the dome of the closed cone. These two groups of *Cycas* species also differ markedly in the size, shape, and construction of their seeds. Closed cone seeds are generally small. Open cone seeds are usually somewhat larger, and some, especially those of plants from islands of the South Pacific and Indian Ocean, contain a layer of spongy material between the sclerotesta and the endosperm that causes the seed to float. This flotation layer probably evolved to facilitate seed dispersal by ocean currents. The sarcotesta or fleshy seed coat is generally somber in color, in shades of brown, yellow-brown, or orange-brown. A few species have a bright orange-red sarcotesta, and the vivid color may play a role in seed dispersal by attracting frugivores such as birds.

The shape of the sclerotesta is also variable. The outline varies from globose (*Cycas panzhihuaensis*) to long ovoid (*C. macrocarpa*). All *Cycas* seeds are slightly compressed longitudinally so that when they are shed, the seed orients itself properly for germination. *Cycas* is the only genus in which the sclerotesta does not have a built-in exit for the emergence of the radicle. The sclerotesta splits at the midpoint of the broad end, enabling the radicle to emerge. The swelling of the female gametophyte causes this splitting as it absorbs water though the sclerotesta. The surface of the sclerotesta is also variable, ranging from smooth (*C. diannanensis*) to fissured (*C. revoluta*) to ridged (*C. wadei*), finally to matted with persistent fibers (*C. beddomei*). So variable are the size, shape, and surface of the sclerotesta that it appears to be a useful diagnostic feature for taxonomic treatments.

Male cones more closely relating to those of the other cycad genera than the female cones, usually erect, ovoid or long elliptical, covered with a fine tomentum that is commonly golden brown. Sporophylls wedge shaped, flat, generally tapering abruptly to a sharp spine that is directed toward the cone apex. In some cases a well-defined spine is absent, in its place only a rudimentary appendage.

Habitat: Fringes of primary rain forest in part of its South Pacific range but more frequently in open situations on limestone outcrops near the shoreline. In Mainland China, Vietnam, Thailand, Myanmar (Burma), and India, *Cycas* is found in tropical deciduous forest and on the borders of bamboo forests. *Cycas* also commonly appears on steep-sided limestone hills rising above the surrounding plains. In northern portions of Western Australia and the Northern Territory, *Cycas* can be found in scattered colonies in extremely hot and dry desert habitats.

Distribution: *Cycas* is more widely distributed than other cycad genera. Species are found as far east as the Tonga Islands and Fiji, west through New Caledonia, Vanuatu, the Solomon Islands, Australia, New Guinea, the Mariana Islands, the Philippines, the Ryukyu Islands, southern Japan, southern China, Taiwan, Vietnam, Laos, Cambodia, Thailand, Malaysia, Indonesia, Myanmar (Burma), India, Sri Lanka (Ceylon), Madagascar, the Comoro Islands, and along the east coast of Africa, where it was probably introduced by humans. Thus the east–west range is about 12,900 km (8000 miles). *Cycas* is found from approximately 8° north of the tropic of Cancer to about 2° south of the tropic of Capricorn, giving an overall north–south range of about 6100 km (3800 miles).

It seems paradoxical that *Cycas,* the first cycad genus described, should centuries later have the reputation of being the most taxonomically confusing. Over the years, more than 130 species, 10 subspecies, 8 varieties, and 6 forms have been described, disputed, confused, and many finally submerged into synonymy under some of the original and more widely accepted species such as *C. circinalis* and *C. rumphii.* Here, 94 species are recognized, 27 endemic to Australia. Since 1990, Kenneth D. Hill of the National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia, has attempted to untangle species definitions within the genus *Cycas.* This undertaking has been made all the more difficult by the huge area the genus covers and the many difficulties posed by rugged terrain and political unrest. Thanks mainly to Hill's boundless energy it appears that *Cycas* will be understood much better than before.

Since prehistoric times *Cycas* has been used as a famine food. Use as a food has caused numerous problems because of the poisons contained in all parts of the plants. If these cycads are not properly prepared by cooking, grinding, and repeated washing, ingestion of the cycad starch can cause serious illness or death. In some areas, such as the Mariana Islands, cycad starch is used not as a famine food but as a staple. Studies of the medical histories of the Chamorro Indians of Guam indicate that cycad toxins can accumulate in a person's system and cause multiple nervous disorders in later years (Sacks 1997).

Cycas leaves are commonly used as decoration. Because of their lasting qualities, they have become popular in flower arrangements. *Cycas revoluta* leaves have long been used in funeral decorations in Asia, but because of this association with death they are not popular in floral arrangements there. Larger specimens of *Cycas* have become widely used in landscaping. As a result of increased demand for *Cycas* specimens, more nurseries are growing cycads for the trade, and I have no doubt that this industry will expand. *Cycas beddomei* is listed in Appendix I of CITES, and all other species are listed in Appendix II.

Cycas aculeata K. D. Hill & H. T. Nguyen in Hill et al. 2002

The epithet for *Cycas aculeata* is derived from *aculeatus,* Latin for prickly, referring to the prominent spines on the petiole. STEMS subterranean or shortly emergent, 15–18 cm (6–7.1 in) in diameter. Cataphylls narrowly triangular, soft, hairy, 8–10 cm (3.1–4 in) long, persistent. LEAVES usually 6–23, deep green above, much lighter below, highly glossy to semiglossy, 1.8–2.5 m (5.9–8.2 ft) long, slightly keeled, emergent leaves densely orange tomentose, the tomentum soon shedding. Petiole 0.6–1.1 m (24–43 in) long, glabrous to pubescent, spiny its entire length. Leaflets in 50–75 pairs, median leaflets lanceolate, 35–52 cm (14–20 in) long, 13–19 mm (0.5–0.7 in) wide, angled forward 45–60°, decurrent for 4–6 mm (0.2 in), spaced 15–28 mm (0.6–1.1 in) apart, slightly keeled in section, midrib raised above, either flat or raised below, margin flat. FEMALE CONES not described. MALE CONES solitary, narrowly ovoid or spindle shaped, 15–20 cm (5.9–8 in) long, 4–6 cm (1.6–2.4 in) in diameter. Sporophylls 22–25 mm (0.9–1 in) long, 12–14 mm (0.5–0.6 in) wide. Sporophyll face 2–3 mm long, apical spine absent. HABITAT: Originally growing in forest understory, but the forests have been severely affected by herbicide spraying during the Vietnam War in the early 1970s. Presently, the habitat consists of dense bamboo, shrubs, and grass regrowth after forest clearing, with the cycad generally found on steep slopes in loamy soil over granite. DISTRIBUTION: Vietnam, Thua Thien-Hue, Phu Loc, Hái Vân Pass.

Cycas aculeata is one of a complex of closely related subterranean stemmed species distributed through northern Vietnam, Laos, northern Thailand, and southern China. *Cycas aculeata* is distinguished by its few long leaves with long petioles armed with long slender spines. Emergent leaves are densely light orange-brown tomentose, the tomentum being shed as the leaf matures. Its small male cones, which exhibit rounded sporophyll faces devoid of any spinelike appendage, also distinguish it. *Cycas aculeata* seems most closely related to *C. balansae* from which it differs by its more numerous leaves with relatively longer petioles, its light orange-brown tomentum, its longer, wider, slightly keeled leaflets, and its longer cataphylls.

Cycas aculeata is a more recently discovered species and at present is poorly documented. Female cones and sporophylls are unknown. The distribution of *C. aculeata* is based on a single collection site, and additional fieldwork will be necessary to document the extent of its range.

I am not aware of any specimens of *Cycas aculeata* in cultivation and therefore cannot comment with any authority on its requirements. Because of its long leaves, *C. aculeata* will not be a popular plant in Asia, where cycads with short leaves are preferred. This will no doubt assist in the conservation of this species. Because of its habitat, *C. aculeata* must be considered a plant only for tropical climates or greenhouse culture.

The conservation status of *Cycas aculeata* cannot be properly addressed at present because of inadequate information. There is a strong possibility that additional areas of distribution will be located in the vicinity of the type locality. Until additional fieldwork is done, the conservation status of *C. aculeata* will remain unknown.

Cycas angulata R. Brown 1810

PLATE 87

The epithet for *Cycas angulata* is derived from *angulatus,* Latin for angled and probably referring to the leaflet arrangement. **Stems** arborescent, erect, usually single but frequently branched, 7.5–9 m (25–30 ft) tall, 40–50 cm (16–20 in) in diameter at the base, older stems losing identifiable leaf base scars and producing a cracked checkerboard bark. Cataphylls narrow, spinelike, about 13 cm (5.1 in) long. **Leaves** as many as 40 in a crown, arching or recurving, 1–1.3 m (3.3–4.3 ft) long, 20–27.5 cm (8–11 in) wide, strongly keeled, glaucous green when fresh, becoming dark green with age. Petiole 25–38 cm (10–15 in) long, 8–11 mm (0.3–0.4 in) in diameter, fully armed with spines 2–4 mm long to completely unarmed in older specimens. Leaflets angled forward then twisted about one-quarter turn up on the leading edge to produce an upward overlapping effect, median leaflets linear lanceolate, gradually acuminate, about 16 cm (6.3 in) long and 4 mm wide, margins flat and straight. **Female cones** open type. Sporophylls pendulous when mature, about 24 cm (9.5 in) long, each with 6–12 ovules just below the sterile lamina, entire sporophyll persistently light brown tomentose. Lamina long triangular, about 60 mm (2.4 in) long and 16 mm (0.6 in) wide, often with several small teeth along the margin, ending in a long, narrow spine. Sarcotesta glaucous gray when immature, orange-brown when ripe. Sclerotesta about 45 mm (1.8 in) long and 35 mm (1.4 in) in diameter, the surface with numerous minute raised areas, giving an overall uneven look. **Male cones** solitary, erect, ovoid, 20–25 cm (8–10 in) long, 12–15 cm (4.7–6 in) in diameter, densely covered with rust brown tomentum. Peduncle short, cone appearing sessile. Sporophylls 4.5–6 cm (1.8–2.4 in) long. Sporophyll face 1.5–2 cm (0.6–0.8 in) wide, apical spine erect, 2–3 cm (0.8–1.2 in) long. **Habitat:** Flat open woodland on sandy soils, usually near streams, from sea level to 30 m (100 ft). All rainfall is in the summer and averages 600–800 mm (24–31 in). High temperatures average 33–36°C (91–96°F) in summer, with lows of 12–15°C (54–59°F) in winter. **Distribution:** Australia, Northern Territory, large stands along the lower reaches of the Foelsche, Robinson, and Wearyan Rivers to the east of Borroloola, all the way to the Gulf of Carpentaria. In Queensland, known only from the Bountiful Island group in the Gulf of Carpentaria.

The range of *Cycas angulata,* Australia's largest species of the genus, appears to have been imperfectly known since Robert Brown described it in 1810. In the past it has been reported from a number of islands and several coastal areas of the Northern Territory, from Darwin all the way to the southern end of the Gulf of Carpentaria. In more recent years all the northern populations have been described as species. At present, *C. angulata* is known only from Borroloola, Northern Territory, south and east to the Bountiful Island group in the Gulf of Carpentaria.

Cycas angulata is not well represented in collections, even within Australia. This was mainly because of the remote habitat and difficulty of collecting this species. In more recent years, increased interest in cycads has resulted in quantities of seed being collected and distributed worldwide. In cultivation, *C. angulata* does not seem to be a difficult subject. A deep container allows its fast-growing taproot room to develop properly. As with some of the other dry-area *Cycas* species, *C. angulata* does not produce its first leaf until a large root is formed. Rainfall in its habitat is during summer, so this species does better if kept on the dry side during cold weather. I have no information about its cold hardiness, but *Cycas* in general seems to tolerate cold weather quite well.

The conservation status of *Cycas angulata* now seems secure. The land on which it grows is in most cases both poor and remote. The colonies I have visited are large and healthy, and regeneration is exceptionally good. Fire is not the problem that it is for some of the other species. I believe it is safe to say that *C. angulata* is not threatened, and it may be one of the more secure cycads in Australia.

Cycas apoa K. D. Hill 1994b

PLATES 88, 89

The epithet for *Cycas apoa* is the common name for this cycad in the language of the Kaka tribe. It is pronounced ap-wah and is a name used around the Sepik River estuary in northeastern New Guinea. **Stems** arborescent, erect, to 2.5 m (8.2 ft) tall. Cataphylls linear, densely orange tomentose. **Leaves** numerous, spreading, 1.8–2.5 m (5.9–8.2 ft) long, terminated by paired leaflets or a spine about 4 mm long, emergent leaves densely tomentose with white and orange hairs, soon becoming glabrous. Petiole generally glabrous, 35–60 cm (14–24 in) long and armed with spines 80–100% of its length. Leaflets glabrous, glossy medium green above when mature, lighter below, angled forward 70–80°, flat, narrowed at their attachment to 2.5–4 mm, spaced 13–25 mm (0.5–1 in) apart, median leaflets 22–32 cm (8.7–13 in) long, 12–15 mm (0.5–0.6 in) wide, midrib often sharply raised, prominent above and below but more so above, margin lightly revolute and strongly undulate, decurrent for 7–10 mm (0.3–0.4 in). **Female cones** open type. Sporophylls about 27 cm (11 in) long, densely gray and orange tomentose, each with four to six ovules. Lamina broadly triangular, about 35 mm (1.4 in) long and 16 mm (0.6 in) wide, irregularly toothed, the apical spine about 13 mm (0.5 in) long, lateral spines not developed. Sarcotesta 3–5 mm (to 0.2 in) thick, orange when ripe. Sclerotesta flattened ovoid, 4.5–5 cm (1.8–2 in) long, 3.5–4 cm (1.4–1.6 in) in diameter, the surface rough and fibrous. **Male cones** not described. **Habitat:** Wet lowland forest areas, often in seasonally inundated sites but usually well away from the littoral zone. **Distribution:** New Guinea, the northern coast from the Huon Peninsula, Papua New Guinea, west to Jazirah Doberai (Vogelkop) Peninsula and Halmahera Island, Indonesia.

Kenneth D. Hill described *Cycas apoa* in 1994. Before that it had mistakenly been referred to *C. circinalis* though it is more closely related to *C. rumphii.* In fact, *C. apoa* and *C. rumphii* share much the same geographic range, the former occurring inland, the latter occupying littoral zones. This relationship does not carry through to their seeds, however, and *C. apoa* lacks the spongy flotation pad inside the sclerotesta. The closest relative of *C. apoa* is apparently *C. scratchleyana. Cycas apoa* is distinguished by its thin leaflets with narrow bases, strongly undulate margins, and reduced size of the lamina and the lateral spines on the megasporophyll. In contrast *C. scratchleyana* has a larger, broader lamina and numerous, clearly defined lateral megasporophyll spines. *Cycas apoa* is on the northern side of New Guinea, *C. scratchleyana* on the southern.

In cultivation, *Cycas apoa* would be expected to require tropical to subtropical growing conditions with constant moisture. Because of its large size and distinctive undulate leaflet margins, it is expected to become a popular landscape plant in tropical areas when seed becomes commonly available. No doubt this cycad will be fast growing, as are other tropical species of the genus. Although not expected to have a high degree of frost tolerance, it may grow in warm temperate climates.

Cycas apoa is not considered threatened. This determination of its conservation status is based on the scattered distribution and the large numbers of the cycad in its habitat.

Cycas arenicola K. D. Hill 1993

The epithet for *Cycas arenicola* is derived from *arena,* Latin for sand, and *-cola,* dweller or inhabitant, alluding to this cycad's occurrence in broken sandstone country. **Stems** arborescent, solitary, rarely branched or suckering, to 1.5 m (4.9 ft) tall, rarely as tall as 2 m (6.6 ft), 15–20 cm (6–8 in) in diameter. Cataphylls densely orange tomentose. **Leaves** numerous, 0.9–1.6 m (3–5.2 ft) long, 17–18 cm (6.7–7.1 in) wide, flat. Petiole loosely brown tomentose, 25–35 cm (10–14 in) long, usually armed with short spines. Leaflets in 90–100 pairs, glabrous, glossy dark green above and densely brown tomentose below, narrowly lanceolate with an apical spine, slightly falcate, median leaflets angled forward 60–90°, not crowded or overlapping and spaced 9–14 mm (0.4–0.6 in) apart, 9–19 cm (3.5–7.5 in) long, 4.5–6.5 mm (to 0.3 in) wide, decurrent at the base for 2–3 mm, narrowed at the base to 3–5 mm (to 0.2 in), midrib not raised or only slightly above, prominent below, margin straight and revolute. **Female cones** open type. Sporophylls 15–20 cm (6–8 in) long, densely gray to orange tomentose, each with four to six ovules. Lamina narrowly triangular, 30–40 mm (1.2–1.6 in) long, 14–18 mm (0.6–0.7 in) wide, margin regularly toothed, with an apical spine about 8 mm (0.3 in) long. Sarcotesta orange with a glaucous coating when ripe. Sclerotesta flattened ovoid, 28–32 mm (1.1–1.3 in) long, 25–29 mm (1–1.1 in) in diameter. **Male cones** solitary, spindle shaped to elongate ovoid, about 25 cm (10 in) long, 5–9 cm (2–3.5 in) in diameter. Sporophylls 15–20 mm (0.6–0.8 in) long, 6–9 mm (0.2–0.4 in) wide. Sporophyll face projecting about 6 mm (0.2 in), not curved backward and downward, apical spine sharply upturned, about 5 mm (0.2 in) long. Sporangia in a single patch somewhat longitudinally divided by a raised ridge. **Habitat:** *Eucalyptus* woodland on soils derived from siliceous sandstone in more or less open situations. Rainfall averages 500–600 mm (20–24 in) annually, falling in summer. High temperatures average 36°C (97°F) in summer, and winter lows 9–12°C (48–54°F). **Distribution:** Australia, Northern Territory, mainly in the upper reaches of the East Alligator and Liverpool Rivers.

Described by Kenneth D. Hill in 1993, the first herbarium material of *Cycas arenicola* was collected in July 1972 but was not recognized as undescribed for a number of years. Its closest relative is *C. calcicola,* with which it shares the unusual feature of persistent tomentum on the underside of the leaves. Its flat leaves, with fewer leaflets per leaf, wider leaflets that taper more gradually and that are less crowded, and small male cones also distinguish *C. arenicola.*

The habitat of *Cycas arenicola* is remote and on Aboriginal land, making access to it rather difficult. For this reason it is not widely cultivated. *Cycas arenicola* will probably respond to the same horticultural conditions as *C. calcicola.* I have found most of the *Cycas* species of the Northern Territory and Western Australia to be difficult subjects in cultivation. This may be a consequence of their often dry habitats. Crown rot in the seedlings may be caused by continually moist soil conditions in cultivation. For this reason I cannot recommend *C. arenicola* as potentially easy to grow.

Cycas arenicola seems to be secure. It is locally abundant in remote and inaccessible areas, and is not considered threatened.

Cycas armstrongii Miquel 1868

PLATE 90

Cycas armstrongii, named in honor of John Francis Armstrong (1820–1902), a collector for the Royal Botanic Gardens, Kew, and at one time resident of the Northern Territory, Australia, is sometimes called fire fern. **Stems** arborescent, erect, 1–4 m (3–13 ft) tall, rarely as tall as 7 m (23 ft), 7.5–10 cm (3–4 in) in diameter. **Leaves** usually 20–30 in mature plants, 0.5–1.2 m (1.6–3.9 ft) long, 22.5–27.5 cm (9–11 in) wide, moderately keeled, often curved slightly backward and downward. Petiole 15–30 cm (6–12 in) long and armed with short straight spines. Leaflets linear, straight, angled forward about 40°, glossy bright green above, pale dull green below, median leaflets 10–13 cm (4–5.1 in) long, 5–10 mm (0.2–0.4 in) wide, margin flat and straight, constricted above and decurrent below. **Female cones** open type. Sporophylls 16.2–20 cm (6.4–8 in) long, glabrous, each with two to four ovules. Lamina triangular, 3.8–5 cm (1.5–2 in) long, 2–3 cm (0.8–1.2 in) wide, with two basal lobes, margin and apex armed with sharp spines. Sarcotesta yellow with a glaucous coating when ripe. Sclerotesta ovoid to subglobose, slightly flattened, 3–3.5 cm (1.2–1.4 in) long, 2.5–3 cm (1–1.2 in) in diameter, light tan, the surface shallowly and unevenly fissured. **Male cones** solitary, ovoid, 17.5–20 cm (7–8 in) long, 9.4–12 cm (3.7–4.7 in) in diameter, densely rust brown tomentose. Peduncle 2.5–3 cm (1–1.2 in) long, densely tomentose. Sporophylls 3–4 cm (1.2–1.6 in) long. Sporophyll face 18–23 mm (0.7–0.9 in) wide, light tan tomentose, the upper half drawn out into an erect point 12–15 mm (0.5–0.6 in) long. **Habitat:** Usually on flat or rising ground under open tropical semideciduous woodland, rarely in rocky situations, the soil of preference usually a sandy loam. Rainfall averages 1500–2000 mm (59–79 in) during the summer monsoon. Summer high temperatures average 20–30°C (68–86°F) with high humidity; winter highs average about the same but the winter months are very dry with much lower humidity. **Distribution:** Australia, Northern Territory, from Darwin in the north to as far south, in scattered small colonies, as Emerald Springs on the Stuart Highway, and from the Cox Peninsula in the west to Annaburroo on the Arnhem Highway in the east.

Cycas armstrongii was described by Friedrich Anton Wilhelm Miquel in 1868 from specimens collected by John Armstrong, a resident of the Northern Territory, Australia, and sent to the Royal Botanic Gardens, Kew, England. During its early history, some taxonomists considered *C. armstrongii* synonymous with *C. media* of northern Queensland. That these two species are different, there is no doubt, with *C. armstrongii* smaller in every respect except height of the stem. *Cycas armstrongii* is also naturally deciduous, and one can expect plants in their habitat to shed most of their leaves in April. Those plants that retain some leaves usually have them burned off in early spring by the annual grass fires. Within a very short time after being burned, the cycads produce a profusion of new leaves, sometimes making them the only plants in the area with green leaves. This trait coupled with this cycad's small size has led to the common name, fire fern.

Cycas armstrongii is certainly the daintiest and one of the most beautiful species of the genus. Its small size, slender trunk, and bright green leaves make it almost unique among the species of the genus. There is no doubt that *C. armstrongii* could become one of the finest garden cycads for the Tropics. The growth rate of *C. armstrongii* is rapid and I have seen cultivated plants attain stems 1 m (3.3 ft) tall in 5 years. Plants in cultivation can produce annual stem length increases of 20–30 cm (8–12 in) and will usually maintain a full head of leaves instead of becoming deciduous as the wild populations do. The one limiting factor of using *C. armstrongii* as a garden plant is the necessity for a tropical climate. Even in subtropical climates, *C. armstrongii* does not reach its potential in growth and appearance. *Cycas armstrongii* normally grows under open *Eucalyptus* parkland, but it will also grow in full sun without having its foliage burned.

The conservation status of *Cycas armstrongii* is secure. Although large areas of its range have been cleared for urbanization in the Darwin area, there are many thousands still to be found over an extensive range. I first saw *C. armstrongii* on the verge of the runway at the Darwin airport. They are also common within the city, growing up through lawns and on vacant lots. Seedling regeneration is prolific over the entire range of *C. armstrongii,* and in many areas the colonies are increasing in size. For these reasons *C. armstrongii* may be considered not threatened.

Cycas arnhemica K. D. Hill 1994c

PLATE 91

The epithet for *Cycas arnhemica* refers to the distribution of this cycad in the central area of Arnhem Land, an Aboriginal reserve in the Northern Territory, Australia. Three subspecies of *C. arnhemica* are recognized: *arnhemica* (described here), *muninga,* and *natja.* STEMS arborescent, erect, usually to 4 m (13 ft) tall but exceptional plants with stems as tall as 7 m (23 ft), 12–19 cm (4.7–7.5 in) in diameter, crown densely dark brown tomentose. LEAVES numerous, flat, 0.7–1.1 m (2.3–3.6 ft) long, semiglossy deep green, emergent leaves densely white tomentose. Petiole persistently white tomentose, 9–36 cm (3.5–14 in) long. Leaflets in 60–135 pairs, bluish deep green, slightly glossy above, white tomentose below, more or less keeled, decurrent for 2.5–4 mm, spaced 7–13 mm (0.3–0.5 in) apart, median leaflets angled forward 45–70°, often falcate, 5–17 cm (2–6.7 in) long, 5–7.5 mm (0.2–0.3 in) wide, midrib not raised or only slightly above, prominent below, margin lightly revolute. FEMALE CONES open type. Sporophylls gray and orange tomentose, each with one to four ovules. Lamina narrowly triangular, 40–70 mm (1.6–2.8 in) long, 15–22 mm (0.6–0.9 in) wide, regularly toothed, with 10–18 lateral teeth 2–5 mm (to 0.2 in) long, apical spine 8–25 mm (0.3–1 in) long. Sarcotesta orange when ripe. Sclerotesta flattened ovoid, 28–33 mm (1.1–1.3 in) long, 27–30 mm (1.1–1.2 in) in diameter. MALE CONES solitary, elongate ovoid, 22–28 cm (8.7–11 in) long, 7–9 cm (2.8–3.5 in) in diameter, orange tomentose. Peduncle short, cone appearing sessile. Sporophyll face 11–13 mm (0.4–0.5 in) wide, apical spine sharply upturned, 11–22 mm (0.4–0.9 in) long, slender. HABITAT: *Eucalyptus*-dominated savanna forests, often near rivers, in soil that is basically deep white to yellow sands over laterites. Rainfall averages 800–1200 mm (31–47 in) annually, falling in summer. Daytime high temperatures average 33–36°C (91–97°F) in summer, and winter lows 18–21°C (64–76°F). DISTRIBUTION: Australia, northeastern Northern Territory, restricted to central Arnhem Land around the Goyder River.

Cycas arnhemica is one of the more recently discovered cycads, described in 1994. Some seed has been collected and distributed, but it is too early to predict how it will grow in cultivation. Most of the species of the Northern Territory, Australia, with the exception of *C. angulata,* have proven difficult to grow under some climatic conditions.

The closest relative of *Cycas arnhemica* is *C. maconochiei,* which may be distinguished by its dense orange tomentum in the crown, rather than dark brown tomentum. There are three subspecies of *C. arnhemica,* on the upper Goyder River in central Arnhem Land (subspecies *arnhemica*), Groote Eylandt (subspecies *muninga*), and on the lower Blyth River in northern Arnhem Land (subspecies *natja*). These three populations are geographically separated and morphologically distinct. Subspecies *arnhemica* is distinguished by its larger leaves with longer, wider, more widely spaced leaflets with margins somewhat curved backward and downward. The leaflets are also angled toward the leaf apex whereas those of subspecies *muninga* and *natja* are generally more or less at right angles to the rachis. Subspecies *muninga* is distinguished by its crowded, numerous, relatively short, narrow leaflets with margins curved backward and downward, and subspecies *natja* may be separated from subspecies *muninga* by its overall smaller stature and smaller leaves, cones, and seeds.

It has been reported that the subspecies of *Cycas arnhemica* are locally abundant and their ranges sizable, leading us to believe that they are not threatened at present nor likely to be in the foreseeable future. Their reproduction in habitat is not good, however, because of the annual grass fires that kill seeds and seedlings.

Cycas arnhemica subsp. *muninga* Chirgwin & K. D. Hill 1996

The subspecific epithet of *Cycas arnhemica* subsp. *muninga* is taken from the common name for this cycad in the Anindilyakwa language of the Aboriginal people of Groote Eylandt, Northern Territory, Australia. STEMS arborescent, erect, to 1.5 m (4.9 ft) tall, rarely as tall as 2.5 m (8.2 ft), 12–20 cm (4.7–8 in) in diameter. LEAVES numerous, 0.7–1.1 m (2.3–3.6 ft) long. Petiole 14–26 cm (5.6–10 in) long. Leaflets in 80–130 pairs, glossy medium green, keeled, glabrous or loosely gray-brown tomentose, median leaflets 6–19 cm (2.4–7.5 in) long, 4–6 mm (0.2 in) wide, angled forward 65–85°, narrowed to 3–5 mm (to 0.2 in) at the base, spaced 4–8 mm (to 0.3 in) apart, margin straight and curved slightly backward and downward. FEMALE CONES open type. Sarcotesta 2–3 mm thick, yellowish when ripe. Sclerotesta 34–37 mm (1.3–1.5 in) long, 29–32 mm (1.1–1.3 in) in diameter. MALE CONES solitary, erect, ovoid, 25–36 cm (10–14 in) long, 8–12 cm (3.2–4.7 in) in diameter. HABITAT: Stabilized sand dunes near the coast. Rainfall averages 800 mm (31 in) annually. Daytime temperatures average 33°C (91°F) in summer, with winter lows of 21°C (70°F). DISTRIBUTION: Australia, Northern Territory, the island of Groote Eylandt in the Gulf of Carpentaria.

Cycas arnhemica subsp. *muninga* is distinguished by its crowded, numerous, and relatively short, narrow leaflets with revolute margins.

Cycas arnhemica **subsp.** ***natja*** K. D. Hill 1996

The subspecific epithet for *Cycas arnhemica* subsp. *natja* is taken from the common name for this cycad in the Bureia language of the Aboriginal people of the Northern Territory, Australia. STEMS arborescent, erect, to 1.5 m (4.9 ft) tall, rarely as tall as 2.5 m (8.2 ft), 12–20 cm (4.7–8 in) in diameter. LEAVES numerous, 0.7–1 m (2.3–3.3 ft) long, glossy medium green, glabrous, flat. Petiole 12–35 cm (4.7–14 in) long. Leaflets in 80–130 pairs, keeled, median leaflets angled forward 60–85°, spaced 4–9 mm (to 0.4 in) apart, 5.5–12 cm (2.2–4.7 in) long, 3–6 mm (to 0.2 in) wide, narrowed to 3–4 mm at the base, margin straight and revolute. FEMALE CONES open type. Sarcotesta 2–3 mm thick, yellowish when ripe. Sclerotesta flattened ovoid, 28–30 mm (1.1–1.2 in) long, 26–28 mm (1–1.1 in) in diameter. MALE CONES erect, spindle shaped, 18–26 cm (7.1–10 in) long, 65–85 mm (2.6–3.3 in) in diameter. HABITAT: Coastal areas in deep sands under *Eucalyptus* woodland. Rainfall averages 800 mm (31 in) annually. Daytime temperatures average 33°C (91°F) in summer, with winter lows of 21°C (70°F). DISTRIBUTION: Australia, Northern Territory, along the north coast of Arnhem Land in the area of the Blyth River, extending to Elcho Island.

Cycas arnhemica subsp. *natja* is smaller than the other two subspecies. Subspecies *muninga* is larger than subspecies *natja* overall, and its leaves and seeds are larger than those of subspecies *natja.* Subspecies *arnhemica* has larger leaves than subspecies *natja,* with longer, wider, and more widely spaced leaflets.

Cycas badensis K. D. Hill 1996

The epithet for *Cycas badensis* refers to Badu Island, Australia, where this cycad is native. STEMS arborescent, erect, usually unbranched, to 8 m (26 ft) tall. Cataphylls narrowly triangular, soft, densely orange woolly, 5–9 cm (2–3.5 in) long. LEAVES numerous, usually terminated by a spine, 1–1.2 m (3.3–3.9 ft) long, moderately keeled, emergent leaves loosely orange-brown tomentose. Petiole 24–26 cm (9.4–10 in) long, 20–25% the total leaf length, glabrous, unarmed, or spiny 5–50% of its length. Leaflets in 100–115 pairs, spaced 8–9 mm (0.3–0.4 in) apart, semiglossy medium to dark green above, lighter below, slightly keeled, basal leaflets not reduced to spines and generally 6–14 cm (2.4–5.5 in) long, median leaflets 11–22 cm (4.3–8.7 in) long, 5–8 mm (0.2–0.3 in) wide, midrib flat above, raised below, margins curved slightly backward and downward, the lower one decurrent about 3 mm. FEMALE CONES open type. Sporophylls 23–28 cm (9.1–11 in) long, densely brown tomentose, each with four to six ovules. Lamina triangular, 5–5.5 cm (2–2.2 in) long, 1.5–3 cm (0.6–1.2 in) wide, regularly toothed, with 22–24 lateral spines 1–4 mm long, 1–2 mm wide, apical spine distinct and 21–25 mm (0.8–1 in) long, 5 mm (0.2 in) wide at its base. Sarcotesta orange-brown when ripe. Sclerotesta flattened ovoid, 30–35 mm (1.2–1.4 in) long, 27–29 mm (1.1 in) in diameter. MALE CONES with sporophylls about 4 cm (1.6 in) long. Sporophyll face about 15 mm (0.6 in) wide, apical spine prominent, upturned, about 4 mm long. Sporangia in a single patch. HABITAT: Tropical grassland under *Eucalyptus.* Rainfall averages 2400–3200 mm (94–126 in) annually, falling in summer. Daytime temperatures average 33°C (91°F) in summer, with winter lows of 21°C (70°F). DISTRIBUTION: Australia, extreme northern Queensland, restricted to Badu Island in the Torres Strait.

Though the existence of the plants had been known for a number of years, *Cycas badensis* was described as recently as 1996 because no taxonomist specializing in the Cycadaceae had studied them sufficiently. In the early 1990s, Kenneth D. Hill started revising *Cycas* for the *Flora of Australia.* The Badu Island plants were investigated and found to be undescribed. This is the northernmost station for *Cycas* in Australia and is included in the range of a complex of species ranging from Badu Island south to Cooktown. Six species were named from this complex: *C. badensis, C. semota, C. silvestris, C. tuckeri, C. xipholepis,* and *C. yorkiana.*

Cycas badensis is rarely found in cultivation because of its remote habitat and the difficulty of collection. I received a few seeds from the Badu Island population in 1987 but the resultant seedlings did not take well to the Los Angeles, California, climate of my garden and were all lost over a period of several years. This cycad should do well in areas of the United States such as southern Florida and Hawaii. There is no doubt that it prefers a tropical to subtropical environment. There is no information on the conservation status of *Cycas badensis.*

Cycas balansae Warburg 1900

PLATE 92

Cycas siamensis subsp. *balansae* (Warburg) J. Schuster 1932

Cycas shiwandashanica H. T. Chang & Y. C. Zhong 1997

Cycas palmatifida H. T. Chang, Y. Y. Huang & Y. C. Zhong in Chang et al. 1998

Cycas balansae is named in honor of Benedict Balansa (1825–1892), French botanical explorer who collected in Tonkin, now northern Vietnam. **Stems** subterranean, cylindrical, usually unbranched, 12–20 cm (4.7–8 in) in diameter, crown not tomentose, leaf remains persistent. Cataphylls 5–7.5 cm (2–3 in) long, 2.5–3 cm (1–1.2 in) wide, triangular lanceolate, brown, densely tomentose below. **Leaves** usually 2–10, flat, 2.5–3.5 m (8–11.5 ft) long, glossy deep green above, paler below. Petiole 1–1.7 m (3.3–5.6 ft) long, armed with 25–43 pairs of straight spines 4–8 mm (to 0.3 in) long spaced 5–25 mm (0.2–1 in) apart. Rachis consistently terminated by paired leaflets. Leaflets in 47–95 pairs, papery, linear, acuminate to caudate acuminate, spaced 16–21 mm (0.6–0.8 in) apart, the narrowed apex 20–25 mm (0.8–1 in) long, median leaflets 20–40 cm (8–16 in) long, 12–18 mm (0.5–0.7 in) wide, angled forward 80–85°, flat, midrib prominent above, obscure below, margins flat and either straight or undulate, the lower one decurrent for 5–8 mm (0.2–0.3 in). **Female cones** closed type. Sporophylls 8–12 cm (3.2–4.7 in) long, brown tomentose, each with two to four glabrous ovules. Lamina ovate, 2–5 cm (0.8–2 in) long, 1–2 cm (0.4–0.8 in) wide, deeply pectinate, with 12–22 soft lateral spines 15–30 mm (0.6–1.2 in) long, 2 mm wide, apical spines not distinct. Sarcotesta yellow when ripe. Sclerotesta ovoid, rough and warty, 25–27 mm (1–1.1 in) long, 20 mm (0.8 in) in diameter. **Male cones** solitary, erect, spindle shaped, 25–60 cm (10–24 in) long, 5–10 cm (2–3.9 in) in diameter, yellow. Peduncle short, cone appearing sessile. Sporophylls wedge shaped, 16–40 mm (0.6–1.6 in) long. Sporophyll face obtusely rounded, about 12–19 mm (0.5–0.7 in) wide, somewhat glabrous, apical spine absent. Sporangia in a single patch. **Habitat:** Rain forest under heavy overhead cover; elevational range not known but could be expected to occur from sea level to probably no more than about 200 m (650 ft). **Distribution:** Vietnam, probably in lowland forest areas to the east of the Annam Highlands and in the area near Hanoi. China, southern portion near the Vietnam border, reported from Yunnan province in Hekou, Jingping, Maguan, and Pingbian counties.

When Otto Warburg (1900) mentioned this species, his description was so concise as to be almost worthless. There were no data on the female sporophyll or leaf detail. Even the information on the male cone was so scanty that it is difficult to believe this species could be identified from the information presented. Julius Schuster treated the taxon as a subspecies of *C. siamensis* in his monograph in *Das Pflanzenreich.* Whether Schuster merely accepted Warburg's description or felt the material available was sufficient to separate it from the other eastern *Cycas* species we can only guess. The political problems affecting the habitat of *C. balansae* has made it all but impossible until more recent times to investigate this species properly.

The taxonomy of *Cycas balansae* is confusing. Other species that are closely related, or possibly the same, are *C. chevalieri, C. inermis,* and *C. simplicipinna.* The type specimen of *C. chevalieri* has leaves similar to those of *C. balansae* and is based on female cone parts. The type of *C. balansae* is based on male cone parts. Both were collected near Hanoi, Vietnam. Are the two the same species? There is no doubt that a good deal of fieldwork will be necessary to answer such questions.

Cycas balansae, with its undulate leaflet margins and upright growth habit, is a very decorative cycad. Apparently, there are a great number of the plants in cultivation in China and Vietnam, where they are used as pot plants. To my knowledge there are no specimens of *C. balansae* outside Vietnam and China. They do not seem to present any problems in cultivation, at least in their native countries. We must expect them to grow best in subtropical to tropical climates in somewhat shaded areas. Propagation material has not been made available outside their native countries, and until it is, many of our questions regarding cultivation remain unanswered.

The conservation status of *Cycas balansae* seems to be reasonably secure. It is locally frequent though never occurring in dense stands, and its area of distribution is very large. Because of its long leaves, *C. balansae* is not as popular a pot plant as species with shorter leaves, and this has given it some measure of protection. Thus *C. balansae* can be classed as not threatened.

Cycas basaltica C. A. Gardner 1923

PLATE 93

Cycas media var. *basaltica* (C. A. Gardner) J. Schuster 1932

The epithet for *Cycas basaltica* refers to this cycad's growing in areas of basalt, a volcanic rock. **Stems** arborescent, erect, solitary, rarely branched, attaining a maximum height of about 3 m (10 ft) but on average about 1 m (3.3 ft) tall and 15–18.8 cm (6–7.4 in) in diameter, base of the stem swollen with a diameter of 30–50 cm (12–20 in), this enlarged portion usually subterranean. Cataphylls narrowly triangular, soft, 7–13 cm (2.8–5.1 in) long. **Leaves** as many as 30 or more in each crown, slightly curved inward to form a somewhat bowl-shaped crown, 0.7–1 m (2.3–3.3 ft) long, 18–30 cm (7.1–12 in) wide. Petiole 10–20 cm (4–8 in) long, completely armed in younger plants but may be unarmed in older plants, in medium sized plants the spines occurring just below the lower leaflets. Leaflets in 70–105 pairs, abruptly acuminate, densely covered with a silvery tomentum, angled forward 70–80°, more or less flat, decurrent on lower edge to next leaflet, basal leaflets gradually reduced to spines, median leaflets 10–17 cm (4–6.7 in) long, 1–1.5 cm (0.4–0.6 in) wide, margin entire and slightly revolute. **Female cones** open type. Sporophylls 21–30 cm (8.3–12 in) long, densely and persistently red-brown tomentose, each with two to six ovules. Lamina lanceolate, 11–16 cm (4.3–6.3 in) long, 14–19 mm (0.6–0.7 in) wide, margin slightly scalloped, regularly toothed, with 6–20 lateral spines 2–4 mm long, 2–3 mm wide, apical spine 20–35 mm (0.8–1.4 in) long. Sarcotesta globular, the surface glabrous and glaucous, becoming yellowish brown when ripe. Sclerotesta light tan, the surface only slightly irregular when magnified, slightly flattened, 25–31 mm (1–1.2 in) long, 23–30 mm (0.9–1.2 in) in diameter. **Male cones** solitary, erect, narrow conical, 18–35 cm (7.1–14 in) long, 75–88 mm (3–3.5 in) in diameter. Peduncle about 30 mm (1.2 in) long and 25 mm (1 in) in diameter. Sporophylls 25–35 mm (1–1.4 in) long. Sporophyll face 11–15 mm (0.4–0.6 in) wide, lightly yellowish brown tomentose, spine erect, curved inward, 5–11 mm (0.2–0.4 in) long. Sporangia in a single patch. **Habitat:** Low hills in open *Eucalyptus* woodland on rocky basalt soil covered by grasses, generally at elevations of 230–260 m (750–850 ft), the preferred exposure west and south. **Distribution:** Australia, extreme northern Western Australia on the Mitchell Plateau in the catchment area of the Drysdale and Lawley Rivers, extending to offshore islands west of Port Warrender.

Cycas basaltica was described in 1923 by Charles A. Gardner from notes and specimens collected on the Kimberley Exploration Expedition of 1921. In his description, he states that the stem diameter is 45 cm (18 in). I have never observed a specimen with a stem diameter of more than 18.8 cm (7.4 in). The only explanation would seem to be that the stem diameter was recorded in centimeters and subsequently published as inches, 18 cm (7.1 in), within the limits observed for this species in its habitat.

As with other species of *Cycas* in Western Australia, *C. basaltica* has been rare in both public and private collections. In more recent times a large amount of seed has been collected and distributed worldwide. In cultivation, especially from seed, *C. basaltica* can be difficult to maintain. Seedlings need a deep pot to allow the long taproot to develop. This taproot is contractile and tends to pull the crown of the seedling well below the soil level. In its habitat, this feature protects the seedling from fire and hot sun, and in general is beneficial to survival. In cultivation it can act in an adverse way by keeping the crown of the seedling too wet, often leading to crown rot. Well-drained soil and careful watering are very important. Since *C. basaltica* is one of the most beautiful of the Australian species of the genus, the added care is well worth the effort.

The conservation status of *Cycas basaltica* seems to be secure. The colonies are extensive and there is adequate regeneration to maintain them. The growing awareness and interest in cycads in general may cause inroads on wild populations through poaching. The beautiful silver tomentose leaves of *C. basaltica* make it a particularly desirable collector's item, and this could easily lead to overcollecting.

Cycas beddomei Thiselton-Dyer 1883a

PLATES 94–97

Cycas circinalis var. *beddomei* (Thiselton-Dyer) J. Schuster 1932

Cycas beddomei is named in honor of Colonel Richard Henry Beddome (1830–1911), English army officer and forestry botanist in India who first described plants of *C. beddomei* erroneously as *C. revoluta.* It is known as Madras cycas, *konda itha* and *per ita* (Indian), and *madhanaka-*

makshi (Telugu dialect in Andhra Pradesh). **Stems** arborescent, erect, solitary or suckering from the base, to 1.9 m (6.2 ft) tall, 11–15 cm (4.3–6 in) in diameter, older stems not displaying a uniform diameter throughout but of greater or lesser diameter along the length, the old leaf bases densely packed with red-brown tomentum. Cataphylls lanceolate, densely red-brown tomentose, usually 7 cm (2.8 in) long and 7 mm (0.3 in) wide. **Leaves** usually 20–30 in mature plants, stiff, straight, 1–1.2 m (3.3–3.9 ft) long, 23–36 cm (9.1–14 in) wide. Rachis somewhat four-angled in cross section. Petiole 10–15 cm (4–6 in) long, the upper third with a few minute spines, base clothed with tufted red-brown tomentum. Leaflets in 50–100 pairs, linear, straight, glabrous, angled forward about 45°, basal leaflets reduced and abruptly replaced by widely spaced spines about 1 mm long, median leaflets moderately crowded, 12–18 cm (4.7–7.1 in) long, 2–3 mm wide, midrib obscure above, prominent below, margin strongly revolute. **Female cones** open type. Sporophylls 15–21 cm (6–8.3 in) long, densely pinkish brown to reddish brown tomentose, each with two to four ovules, coning November–December, seeds ripening March–May. Lamina ovate lanceolate, 60–76 mm (2.4–3 in) long, 20–25 mm (0.8–1 in) wide, tapering to a long acuminate point, margin strongly toothed, lobed. Sarcotesta yellow to brown when ripe. Sclerotesta ovoid, 32–36 mm (1.3–1.4 in) long, 21–25 mm (0.8–1 in) in diameter, the surface with a peculiar layer of branching hairlike fibers that remains after the sarcotesta has been removed. **Male cones** solitary, oblong ovoid, 22–33 cm (8.7–13 in) long, 5–7.5 cm (2–3 in) in diameter. Peduncle very short, cone appearing sessile. Sporophylls 2–3.5 cm (0.8–1.4 in) long. Sporophyll face triangular to rhomboid, 1–2 cm (0.4–0.8 in) wide, apical spine about 2 cm (0.8 in) long, ascending on sporophylls at the base of the cone, deflexed on those in the upper half or two-thirds. Sporangia in a single patch. **Habitat:** Well-drained rocky slopes of dry, brush-covered hills at elevations of 300–900 m (980–3000 ft), preferring open sunny areas. Daytime temperatures are in the range 25–35°C (77–95°F), nighttime about 20°C (68°F). **Distribution:** India, Tamil Nadu and Andhra Pradesh states, in the hills of Chittoor and Cuddapah districts.

Cycas beddomei is the least known of the Indian species of *Cycas* and is found in only two small areas of dry hills. The small size of this cycad and the extremely narrow leaflets are doubtless an adaptation to the dry environment.

Male plants of *Cycas beddomei* tend to form clumps by suckering from the base and are said to be common. In contrast, female plants are always solitary and fewer in number. The habitat of *C. beddomei* is prone to frequent forest fires, but these do not seem to have an adverse effect on this cycad's survival. *Cycas circinalis* is found in nearby areas, but nowhere are the two species found growing together, nor are natural hybrids between the two known.

Cycas beddomei is quite rare in both private and public gardens. In its habitat, viable seed of *C. beddomei* is scarce. This may be a result of young male cones being sought by ayurvedic physicians and their agents. They are collected or purchased from the local inhabitants and so are not commonly available in the field. This scarcity of male cones no doubt has an effect on pollination of the female cones. The male cones are known as *per ita* and are supposed to have a cooling effect when prepared in a dried and sugared form. They are also used to treat rheumatism and muscular pains. The pith of the stem is said to be used to treat stomach pains. Unlike most *Cycas* seeds, the seed has an additional layer to the coat, found between the sarcotesta (fleshy coat) and sclerotesta (the shell) and composed of a thick, white, branching hairlike substance. It does not come off with removal of the sarcotesta and becomes slimy when in contact with water, which it seems to retain. Even when seeds have been cleaned by birds and bears, this layer remains. The function of this substance is not known but it may well be water storage, assisting in the germination of the seed.

The scarcity of *Cycas beddomei* in collections and thus the lack of experience in its cultivation make it quite difficult to assess its horticultural requirements. It is probably safe to assume that its requirements would be well-drained soil mix and a warm climate or protection from cold weather. It would be most beneficial to botanical gardens and collectors alike if seeds of this interesting species could be made available before the wild populations become more restricted. Efforts should be made to establish breeding colonies in other parts of the world.

The conservation status of *Cycas beddomei* is not good. The scarcity of plants in its habitat has caused this species to be the only one in the genus to be included in Appendix I of CITES. It is considered one of the most endangered species of the genus and should be rigidly protected.

Cycas bifida (Thiselton-Dyer) K. D. Hill in Hill et al. 2002

PLATES 98, 99

Cycas rumphii var. *bifida* Thiselton-Dyer 1902
Cycas longipetiolula D. Y. Wang in Wang & Chen 1996
Cycas multifrondis D. Y. Wang in Wang & Chen 1996

Cycas bifida, the epithet referring to the dichotomously divided leaflets of this cycad, is called *chaye sutie.* **Stems** generally subterranean, to 40 cm (16 in) long, 10–30 cm (4–12 in) in diameter. Cataphylls broad lanceolate, 11–14 cm (4.3–5.5 in) long, 5–6 cm (2–2.4 in) wide, densely brown tomentose. **Leaves** two to five, glossy dark green, 2–5 m (6.6–16 ft) long, 80–90 cm (32–35 in) wide. Petiole 1.1–1.6 m (3.6–5.2 ft) long, armed with 40–78 pairs of spines 3–5 mm (to 0.2 in) long, spaced 15–25 mm (0.6–1 in) apart. Leaflets in 27–44 pairs, glossy deep green, papery to leathery, linear, apex gradually acuminate, median leaflets 30–60 cm (12–24 in) long, 1.8–2.5 cm (0.7–1 in) wide, one to three times dichotomously divided, petiolule 5–35 mm (0.2–1.4 in) long, midrib prominent above, flat below, spaced 6–9.5 cm (2.4–3.7 in) apart, margins straight and flat, the lower one decurrent 10–15 mm (0.4–0.6 in). **Female cones** closed type, 20–25 cm (8–10 in) high, 30–40 cm (12–16 in) in diameter. Sporophylls 19–23 cm (7.5–9.1 in) long, densely red-brown tomentose, each with six to eight ovules. Lamina ovate, 8–12 cm (3.2–4.7 in) long, 2.5–5 cm (1–2 in) wide, margin regularly divided into 12–15 pairs of segments 2–5 cm (0.8–2 in) long, 1–2 mm wide, apical segment 3–6.5 cm (1.2–2.6 in) long, 3–8 mm (to 0.3 in) wide. Sarcotesta yellow to yellow-brown when ripe. Sclerotesta flattened ovoid, about 2.5 cm (1 in) long and 2 cm (0.8 in) wide, rough and warty. **Male cones** solitary, erect, spindle shaped, cylindrical, 35–55 cm (14–22 in) long, 6–8 cm (2.4–3.1 in) in diameter, light yellow tomentose. Peduncle about 25 mm (1 in) long. Sporophylls 20–25 mm (0.8–1 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) wide, densely tomentose, apical spine erect, about 1 mm long, with one to three minute teeth on either side. Sporangia in a single patch. **Habitat:** Mixed, dense, low, evergreen or deciduous forest or bamboo woodland, often around or on steep limestone outcrops. **Distribution:** China, Guangxi autonomous region. Vietnam, northeastern part of the country near Làng Son.

In 1899 H. B. Morse collected a *Cycas* in southern China with remarkable bifid leaflets. This specimen was brought to the attention of William T. Thiselton-Dyer of the Royal Botanic Gardens, Kew, England, who described it as *C. rumphii* var. *bifida* in 1902. It is one of the plants in the complex that have dichotomously divided leaflets and, generally, subterranean stems. Variety *bifida* was elevated to the rank of species by K. D. Hill in 2002. It differs from *C. micholitzii,* another member of the complex, in its more numerous leaves, the size and shape of the female cone and sporophylls, the greater number of ovules, the greater number of divisions in the leaflets, and longer petiolules.

The habitat of *Cycas bifida* straddles the China-Vietnam border, making travel there difficult because of the occasional clashes that took place between the two countries. Because the region was considered a war zone, the Chinese government prohibited Europeans from entering the area. This may ultimately prove beneficial in protecting the remaining cycads. On the Vietnam side of the border, many land mines remain in place and the area is understandably not visited often.

China has established the Longgang Nature Reserve in Longzhou, Guangxi autonomous region, for the protection of *Cycas bifida,* which is considered endangered by the Chinese government. In 1992 the Institute of Botany, Academia Sinica, published the *China Plant Red Data Book,* treating threatened plants, in which *C. bifida* is said to be found in two distinct areas, one in Yunnan, one in Guangxi, approximately 300 km (190 miles) apart. In the description, the trunk height of *C. bifida* is given as "to 4 m [13 ft] tall." Since *C. bifida* has a subterranean stem, this height must be in error, or there is the possibility that plants with leaves similar to those *C. bifida* but with arborescent trunks may occur in China. Additional fieldwork is sorely needed.

In the area of the Red River, called the Hong in Vietnam and the Yuan in China, *Cycas bifida* has been observed growing together with *C. multipinnata.* It is interesting to note that no apparent hybrids have been found. The explanation for this is not known because it has been shown that most *Cycas* species hybridize easily, so there must be a barrier created by differences in insect pollinators or coning times. Additional research will be necessary to fully understand this lack of hybridization.

Cultivation of *Cycas bifida* does not present any problems as long as the plant is grown in tropical to subtropical climates, or in a greenhouse. Because of the hardiness shown by *Cycas* in general, this species may also grow in temperate climates. It is rare in collections with a few plants known to be in cultivation in China at the Fuzhou Arboretum and Xiamen Botanical Garden, Fujian province, and Shenzhen Fairy Lake Botanical Garden, Guangdong province. There are also a fair number of plants in cultivation in the United States, Australia, and Thailand. The few plants in the Chinese institutions have grown well and coned. It is hoped that they will be entered into an artificial propagation program to increase the numbers of this cycad in cultivation.

Cycas bifida is not considered to be at risk. Although the species and its habitat have been reduced by collecting, agriculture, and forestry development, it is still frequent in many areas, especially in Vietnam.

Cycas bougainvilleana K. D. Hill 1994b

PLATE 100

The epithet for *Cycas bougainvilleana* refers to this cycad's center of distribution on Bougainville, largest of the Solomon Islands. **Stems** arborescent, erect, to 8 m (26 ft) tall, rarely as tall as 12 m (39 ft). Cataphylls linear, densely orange tomentose, 8–16 cm (3.2–6.3 in) long. **Leaves** numerous, 1.8–3.1 m (5.9–10 ft) long, apex terminated by paired leaflets or a spine 3–11 mm (to 0.4 in) long, emergent leaves densely and loosely white and orange tomentose, soon becoming glabrous. Petiole 30–65 cm (12–26 in) long, usually glabrous, armed 10–100% of its length or sometimes completely unarmed. Leaflets in 65–130 pairs, dull to bluish green when fresh, glossy green when mature, lighter below, falcate, angled forward 60–85°, flat, narrowed at the attachment to 4.5–7 mm (to 0.3 in), spaced 17–28 mm (0.7–1.1 in) apart, median leaflets 20–35 cm (8–14 in) long, 13–18 mm (0.5–0.7 in) wide, midrib not sharply raised and equally prominent above and below, margin straight and lightly revolute, decurrent for 7–15 mm (0.3–0.6 in). **Female cones** open type. Sporophylls 25–35 cm (10–14 in) long, densely gray and orange tomentose, each with six to nine ovules. Lamina narrowly triangular, 5.5–11.5 cm (2.2–4.5 in) long, 3–5 cm (1.2–2 in) wide, regularly toothed, with 16–32 lateral spines 4–9 mm (to 0.4 in) long, apical spine 12–22 mm (0.5–0.9 in) long. Sarcotesta 3–5 mm (to 0.2 in) thick, orange when mature. Sclerotesta flattened ovoid, 40–55 mm (1.6–2.2 in) long, 36–45 mm (1.4–1.8 in) in diameter. **Male cones** erect, narrowly ovoid, 35–55 cm (14–22 in) long, 10–15 cm (4–6 in) in diameter, pale fawn to pale orange tomentose. Sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face 17 mm (0.7 in) high, 16–18 mm (0.6–0.7 in) wide, not curved backward and downward, apical spine broad, sharply upturned, somewhat reduced, about 2 mm long. Sporangia in a single patch about 39 mm (1.5 in) long. **Habitat:** Low-elevation moist forest on stabilized calcareous coral sand dunes and headlands, generally confined to coastal and near-coastal sites. **Distribution:** Papua New Guinea, confined to near-coastal sites on New Britain, and Bougainville and other (?) Solomon Islands, "sporadic but locally abundant" (K. D. Hill).

Cycas bougainvilleana is one of several species from New Guinea and vicinity. As the name implies, it is native to the island of Bougainville. Another disjunct and less robust colony of *C. bougainvilleana* occurs on the island of New Britain. The species is distinguished by its very broad, falcate, glossy leaflets with broad, low midrib and by the relatively short, thick, partially armed petiole. It is also distinctive in its large and narrowly triangular megasporophyll blade, armed with 16–32 lateral spines 4–9 mm (to 0.4 in) long. Kenneth D. Hill considers *C. seemannii* of the Fiji Islands to be the closest relative of *C. bougainvilleana.*

I am not aware of any specimens of *Cycas bougainvilleana* in cultivation. From its description it is an apparently very handsome cycad that could become a popular landscape plant for tropical and subtropical areas. Its very large size and distinctive foliage should make it an impressive addition to any collection or landscape design. Although *C. bougainvilleana* is from a tropical habitat, it should be tested in temperate climates because several tropical *Cycas* species have displayed frost resistance that was completely unexpected.

The conservation status and range of *Cycas bougainvilleana* are not well documented, but according to Hill the distribution of *C. bougainvilleana* is "sporadic but locally abundant." For this reason the species is not considered threatened.

Cycas brachycantha K. D. Hill, H. T. Nguyen & L. K. Phan in Hill et al. 2002

PLATE 101

The epithet for *Cycas brachycantha* is derived from *brachys*, Greek for short, and *acantha*, spine, referring to the generally short petiolar spines. **Stems** subterranean to shortly arborescent, to 1 m (3.3 ft) long, 9–12 cm (3.6–4.7 in) in diameter. Cataphylls narrowly triangular, tomentose, articulated, 5–8 cm (2–3.2 in) long. **Leaves** usually 5–10, very glossy deep green, 1.4–2.5 m (4.6–8.2 ft) long, slightly keeled to flat, apex consistently terminated by paired leaflets, emergent leaves densely white tomentose, becoming glabrous with age. Petiole 50–90 cm (20–35 in) long, 35–45% the total leaf length, glabrous, spiny 50–100% of its length. Leaflets in 50–105 pairs, much lighter below than above, spaced 10–21 mm (0.4–0.8 in) apart, apex not spiny but softly acuminate, basal leaflets not gradually reduced to spines and generally 15–20 cm (6–8 in) long, median leaflets 20–25 cm (8–10 in) long, 10–14 mm (0.4–0.6 in) wide, flat, decurrent for 6–8 mm (0.2–0.3 in), angled forward 70–85°, midrib raised above, flat below, margin undulate but not revolute. **Female cones** closed type. Sporophylls 8–12 cm (3.2–4.7 in) long, densely brown tomentose, each with two to four glabrous ovules. Lamina ovate, 25–40 mm (1–1.6 in) long, 15–25 mm (0.6–1 in) wide, deeply pectinate, with 14–22 soft lateral spines 15–25 mm (0.6–1 in) long, 2.5 mm wide, apical spine not distinct. Sarcotesta 1–2 mm thick, yellow, not glaucous, fibrous layer absent. Sclerotesta ovoid, rough and warty, 25–27 mm (1–1.1 in) long, 20 mm (0.8 in) in diameter, spongy endocarp absent. **Male cones** solitary, spindle shaped, 12–14 cm (4.8–5.5 in) long, 3–4 cm (1.2–1.6 in) in diameter, yellow. Sporophylls 12–15 mm (0.5–0.6 in) long, 6–10 mm (0.2–0.4 in) wide. Sporophyll face without an apical spine. **Habitat:** Generally on the crest of limestone ridges in crevices that usually do not contain soil, under closed evergreen forest canopy. **Distribution:** Vietnam, a small area in Bac Can province in the northern part of the country.

Cycas brachycantha is one of a closely related complex of generally stemless species distributed through northern Vietnam, Laos, northern Thailand, and Yunnan province and Guangxi autonomous region in southern China. It can be distinguished by its small stature, long leaves with short petiolar spines, small male cones without apical spines on the sporophylls, and small megasporophylls. Although generally stemless, very old plants can develop a slender, often decumbent aerial stem.

Cycas brachycantha is not known to be in cultivation outside Vietnam, though it is sometimes found as a garden plant in northern Vietnam. It is not a particularly decorative species and thus not in great demand as a garden subject. Judging by its distribution and habitat, it would do best in semitropical to tropical areas with overhead protection.

The conservation status of *Cycas brachycantha* is good. Kenneth D. Hill reports large numbers of this species in Ba Be National Park in northern Vietnam, where it receives adequate protection.

Cycas brunnea K. D. Hill 1992

PLATE 102

The epithet for *Cycas brunnea* is derived from *brunneus,* Latin for brown, referring to the color of the tomentum on the emergent leaves, distinguishing this cycad from related species. **Stems** arborescent, to 2 m (6.6 ft) tall, rarely as tall as 5 m (16 ft), 17–23 cm (6.7–9.1 in) in diameter. **Leaves** numerous, 1.2–1.7 m (3.9–5.6 ft) long, 30–40 cm (12–16 in) wide, usually keeled, emergent leaves densely brown tomentose, becoming glabrous with age. Petiole glabrous or with persistent gray tomentum, 28–60 cm (11–24 in) long, lightly armed with short spines. Leaflets in 80–120 pairs, glaucous when newly emergent, becoming glossy grayish green when mature, median leaflets 17–27 cm (6.7–11 in) long, 6–7.5 mm (0.2–0.3 in) wide, narrowed to 4–5 mm (0.2 in) at the base, the midrib not raised or only slightly above, prominent below, margins curved slightly backward and downward, the lower one decurrent for 2–6 mm (to 0.2 in). **Female cones** open type. Sporophylls 28–32 cm (11–13 in) long, orange tomentose, each containing four to six ovules. Lamina narrowly triangular, 45–80 mm (1.8–3.2 in) long, 18–22 mm (0.7–0.9 in) wide, with a few scattered and inconspicuous serrations along the upper margins, apical spine 16–32 mm (0.6–1.3 in) long. Sarcotesta orange when ripe, often glaucous. Sclerotesta ovoid to globose and somewhat flattened, 36–39 mm (1.4–1.5 in) long, 28–32 mm (1.1–1.3 in) in diameter. **Male cones** solitary, long ovoid, 19–21 cm (7.5–8.3 in) long, 10–13 cm (4–5.1 in) in diameter, brown tomentose. Peduncle very short, cone appearing almost sessile. Sporophylls 50–55 mm (2–2.2 in) long. Sporophyll face 17–20 mm (0.7–0.8 in) wide, red-brown tomentose, apical spine sharply upturned, about 28 mm (1.1 in) long, slender. Sporangia in a single patch covering the underside of the sporophyll. **Habitat:** Exposed situations along open creek valleys in gorges or in wooded savanna, in sandy soil derived from limestone or decomposed sandstone. Rainfall averages 500–1000 mm (20–40 in) annually, falling mainly in summer. Daytime temperatures average 20–30°C (68–86°F) during the entire year. **Distribution:** Australia, straddling the border between Queensland and Northern Territory, a relatively small area at the southern end of the Gulf of Carpentaria. There are several populations near the headwaters of Lawn Hill Creek and its tributaries in Queensland, and it has been reported from Wollogorang station in the Northern Territory.

In 1971 Peter Latz collected specimens of a *Cycas* on Lawn Hill station in northwestern Queensland that were assigned to *C. angulata.* In 1972 the late John R. Maconochie, while revising the *Cycas* of Australia, collected specimens at Running Waters station on Lawn Hill Creek, which were also assigned to *C. angulata.* While Kenneth D. Hill was involved in a study of *Cycas* of Queensland, he found sufficient differences between these populations and *C. angulata* of the Northern Territory to warrant the description of a new species, *C. brunnea,* in 1992.

Cycas brunnea may be distinguished from *C. angulata* by its broader, more glaucous leaflets with flatter margins, slightly smaller seeds, and fewer ovules per sporophyll, 4–6 versus 6–12 in *C. angulata. Cycas angulata* also produces much taller stems than *C. brunnea.*

There is no information on the cultivation of *Cycas brunnea,* but it should not differ from that of *C. angulata,* which occurs in similar habitats. In general, *Cycas* from dry areas needs good drainage and a deep container to give the taproot sufficient depth to develop properly. Bright light is also beneficial for all cycads with gray leaves. This species will probably not be frost tolerant.

Cycas brunnea is not considered threatened. Now that the plants have been described as a separate species, however, there will doubtless be increased demand by collectors for propagation material. Although the habitat as now known is somewhat restricted, some of the populations occur within Lawn Hill National Park, where they receive protection.

Cycas cairnsiana F. Mueller 1876a

PLATE 103

Cycas cairnsiana, named in honor of William Wellington Cairns, governor of Queensland, Australia, has been called Mount Surprise blue. **Stems** arborescent, erect, rarely branched, to 2.5 m (8.2 ft) tall, rarely as tall as 5 m (16 ft), 12–16 cm (4.7–6.3 in) in diameter, the subterranean portion of the stem prominently swollen. Cataphylls slender, thickly bright orange-brown tomentose. **Leaves** numerous, arching and bow shaped, very glaucous light blue, 0.6–1.1 m (2–3.6 ft) long, when flattened 14–17 cm (5.5–7 in) wide, strongly keeled, emergent leaves densely and loosely orange-brown tomentose. Petiole glabrous, 18–27 cm (7.1–11 in) long and armed 10–100% of its length with spines. Leaflets in 90–140 pairs, narrowly linear, spaced 5–6 mm (0.2 in) apart, median leaflets 8–18 cm (3.2–7.1 in) long, 2–3 mm wide, midrib not raised or only slightly above, prominent below, margins strongly revolute and ending in a pungent apex, the lower margin narrowed at the attachment and decurrent for 2–3 mm, the upper scarcely narrowed. **Female cones** open type. Sporophylls 16–21 cm (6.3–8.3 in) long, covered with a persistent orange-brown to tan colored tomentum, with two to four ovules attached just below the lamina. Lamina narrowly triangular, 45–70 mm (1.8–2.8 in) long, 15–25 mm (0.6–1 in) wide, margins regularly toothed, apical spine 1.5–2 cm (0.6–0.8 in) long. Sarcotesta yellowish brown when ripe and strongly glaucous. Sclerotesta ovoid to subglobose, 3–3.5 cm (1.2–1.4 in) long, 2.5–3 cm (1–1.2 in) in diameter, light tan, the surface slightly irregular to almost smooth. **Male cones** solitary, sometimes two or three (?), erect, long ovoid, 16–24 cm (6.3–10 in) long, 7–10 cm (2.8–4 in) in diameter, finely covered with a rust brown tomentum. Peduncle short, cone appearing sessile. Sporophylls 22–34 mm (0.9–1.3 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) wide, apical spine erect, 6–9 mm (0.2–0.4 in) long. Sporangia in two patches separated by a medial ridge. **Habitat:** Dry rocky terrain in open woodland consisting of *Eucalyptus, Grevillea,* and *Melaleuca* surrounded by grasses, in decomposed granite soil between large granite boulders, at elevations of 450–550 m (1500–1800 ft). Rainfall averages 1350 mm (53 in) annually, three-quarters falling in summer, December–April. Daytime high temperatures range from 32°C (90°F) in summer to 7°C (45°F) in winter, with the lowest recorded –3°C (27°F). **Distribution:** Australia, northeastern Queensland, Newcastle Range in the vicinity of the towns of Mount Surprise and Forsayth.

Ferdinand von Mueller described *Cycas cairnsiana* in 1858 while employed as a government botanist in Australia. During his tenure in this position he described no fewer than five species of *Cycas,* two from New Guinea, and eight of *Macrozamia.* He is considered one of the foremost researchers of the Australian cycads. The closest relatives of *C. cairnsiana* are *C. couttsiana* and *C. platyphylla.* These two other species also have glaucous new foliage and keeled leaves. For a number of years the name *C. cairnsiana* was misapplied to what is now *C. platyphylla.* During this time the Mount Surprise plants were "discovered" and thought to be undescribed. The taxonomic mix-up was corrected by Kenneth D. Hill in 1992 when the name *C. cairnsiana* was correctly applied to the Mount Surprise population.

I have observed hundreds of individuals of *Cycas cairnsiana* while surveying their habitat by helicopter, but I have never seen one with leaves of a greenish color. Without exception, all plants had the striking blue foliage color. This intensely blue color, and the narrow leaflets, easily separate *C. cairnsiana* from the other blue Queensland species. Strange as it may seem, *C. cairnsiana* is not often seen in cultivation, even though it is locally common in its habitat. This beautiful plant, with its spreading blue-gray leaves, seems to make the transition from summer- to winter-rainfall areas without noticeable problems. This cycad does best with full sun and well-drained soil. Although growth is somewhat slow from seed, it will make good progress if given sufficient fertilizer.

The conservation status of *Cycas cairnsiana* is good. There are at least two large populations, showing liberal regeneration. The land is poor where these cycads grow, so no large-scale eradication attempts have been initiated to protect cattle. The only conservation problem in the foreseeable future might be the overcollecting of this cycad because of the beautiful blue color of its foliage. A considerable amount of seed is produced each year, most of which matures without incident. The habitat of *C. cairnsiana* is so dry that little brush and grass grow around the plants, so they are protected from the annual fires.

Cycas calcicola Maconochie 1978

PLATES 104–106

Cycas calcicola, the epithet derived from *calx,* Latin for lime, and *-cola,* dweller or inhabitant, referring to the distribution of this cycad in limestone areas north of Katherine, Northern Territory, Australia, is called zamia bush, zamia palm, and ricket bush, the last alluding to incidents of stock poisoning with symptoms resembling those of rickets. **Stems** erect or decumbent, often suckering from the base to form clumps, to 3 m (10 ft) long, rarely as long as 5 m (16 ft), 17–30 cm (6.7–12 in) in diameter. Cataphylls narrowly triangular, soft. **Leaves** numerous, dark green, straight or lightly arching, 80–90 cm (32–35 in) long, 15–20 cm (6–8 in) wide, flat, emergent leaves densely and persistently silver tomentose. Petiole round to four-angled toward the base, somewhat tomentose, 17.5–27.5 cm (7–11 in) long, 8–10 mm (0.3–0.4 in) in diameter. Leaflets in 100–140 pairs, silver tomentose or glabrous above, persistently tomentose below, basal leaflets reduced to spines, median leaflets 8–12 cm (3.2–4.7 in) long, 2.5–4 mm wide, straight to slightly curved, angled slightly forward, not decurrent at the attachment, spaced 4–6 mm (0.2 in) apart, apex with a spine 1 mm long, midrib flat above, raised below, margin entire and strongly revolute. **Female cones** open type. Sporophylls loose to pendent when bearing ripe seed, 12–18 cm (4.7–7.1 in) long, brown tomentose though the upper surface eventually glabrous, each with four to six ovules. Lamina elliptical to rhombic, 2–2.5 cm (0.8–1 in) long, 1.5–2 cm (0.6–0.8 in) wide, margin regularly toothed, with 26–36 lateral spines 2–4 mm long, apical spine 6–10 mm (0.2–0.4 in) long. Sarcotesta brown-orange when ripe, with a glaucous coating. Sclerotesta short ovoid to globular, 32–35 mm (1.3–1.4 in) long, 25–27 mm (1–1.1 in) in diameter, the surface covered with a network of shallow grooves. **Male cones** solitary, erect, narrow ovoid, 17–30 cm (6.7–12 in) long, 5–7 cm (2–2.8 in) in diameter, gray-orange tomentose. Peduncle about 25 mm (1 in) long. Sporophylls 15–25 mm (0.6–1 in) long. Sporophyll face 6–10 mm (0.2–0.4 in) high, 8–12 mm (0.3–0.5 in) wide, apical spine upright, slightly hooked, 7–10 mm (0.3–0.4 in) long. **Habitat:** Hot, dry, more or less flat areas with numerous limestone outcrops, or in the northern populations on sandstone; associated with *Eucalyptus* and *Livistona* at elevations of 123–155 m (400–500 ft). **Distribution:** Australia, Northern Territory, the type locality just north of Katherine with two other disjunct populations at Bamboo Creek and the East Alligator River south of Darwin.

Cycas calcicola is not well represented in botanical gardens and private collections. This is surprising, as it is one of the most striking and beautiful cycads of Australia. The leaves are covered with a unique fine, silvery tomentum that gives a somewhat glistening appearance. This effect is enhanced when the wind moves across the leaves, with varying reflections and highlights produced. There are two distinct forms or ecotypes of *C. calcicola.* Plants in the Katherine area are more robust in trunk size, and length and width of leaves, and are normally found growing among limestone outcrops and in calcareous soils. Plants in the Tabletop Range area south of Darwin are much smaller in every respect and grow in sand and decomposed sandstone. The tomentum on the leaves of these latter populations is at first a distinct rust brown, with the sun later bleaching it on the upper leaf surface to a silvery gray. When the wind picks up the leaves of this form it presents an alternating combination of silver and gold, the beauty of its appearance almost beyond description.

In cultivation, *Cycas calcicola* can sometimes be difficult to maintain. Viable seed germinates readily, then proceeds to pull itself into the ground by its contractile roots. In the wild, this submergence of the plant's crown protects it from the annual grass fires and also from predators. In cultivation, it seems to create a problem with crown rot. Ample water given when a seedling, especially in the normally dry winter months, can lead to the loss of the plant. It cannot be overstressed that a very porous soil mix is mandatory for this cycad as well as others that grow in the dry Tropics. Once the plant gains some size, crown rot is not a major problem. *Cycas calcicola* can withstand short periods of frost with damage limited to leaf burn or, at worst, defoliation. Subsequently, plants will produce new leaves in spring with the advent of warm weather. The seedling leaf of *C. calcicola* is almost glabrous, with bright green leaflets that are longer and narrower than those produced by the adults.

The habitat of *Cycas calcicola* is generally burned over in the spring of each year just before the rains begin.

Most of the cycads are defoliated but they soon start production of new leaves and cones. The cycads do not seem to be unduly damaged by these annual fires, other than the charring of their stems. In fact, it appears that a fire symbiosis exists for *C. calcicola,* causing the production of new leaves and cones. I received word from a friend in Australia who has been working on an interesting experiment. In the spring of each year he stacks dry grass around each of his garden cycads, sets fire to it, and burns off the old leaves. He states that new foliage emerges in 1–2 weeks, and that without the burning, new leaves may not be produced during the whole season. This is not too surprising when one considers that many cycad species are engineered to withstand fire without damage to the stem apex.

The conservation status of *Cycas calcicola* is fairly secure. It still occurs in large numbers and actively regenerates in its habitat. The form from south of Darwin sometimes occurs in colonies of many thousands. The Katherine populations seem to be much smaller and more scattered. Numerous plants have been removed for commerce or by collectors. Except for the Katherine form, *C. calcicola,* because of its widespread distribution and large numbers remaining in habitat, is not considered at risk.

Cycas campestris K. D. Hill 1994a

The epithet for *Cycas campestris* is derived from *campester,* Latin for plains or flat areas and alluding to this cycad's habitat. **Stems** erect, usually unbranched, to 3 m (10 ft) tall, rarely as tall as 6 m (20 ft), and about 20 cm (8 in) in diameter. Cataphylls densely orange tomentose. **Leaves** numerous, 0.8–1.7 m (2.6–5.6 ft) long, more or less flat, apex usually terminated by paired leaflets, emergent leaves densely and loosely orange tomentose, becoming glabrous when mature. Petiole generally glabrous, 15–50 cm (6–20 in) long, armed with spines for more than half its length. Leaflets in 80–115 pairs, glabrous, at first dull green or slightly bluish green, becoming glossy medium green when mature, slightly keeled, narrowed to 2–3.5 mm at the base, spaced 6.5–8 mm (0.3 in) apart, median leaflets angled forward 60–85°, 9–16 cm (3.5–6.3 in) long, 5.5–8 mm (0.2–0.3 in) wide, midrib less prominent above than below, margins flat and entire, the lower one decurrent for 1.5–4 mm. **Female cones** open type. Sporophylls 13–25 cm (5.1–10 in) long, densely pale brown tomentose, each with two to six ovules. Lamina triangular, 3.5–5 cm (1.4–2 in) long, 2–4 cm (0.8–1.6 in) wide, regularly and finely pectinate, with 20–36 lateral spines 4–9 mm (to 0.4 in) long, apical spine 1–3 cm (0.4–1.2 in) long. Sarcotesta 2–3.5 mm thick, orange when ripe. Sclerotesta flattened long ovoid, 29–40 mm (1.1–1.6 in) long, 23–29 mm (0.9–1.1 in) in diameter, the surface covered with a network of shallow grooves. Chalaza extended about 5 mm (0.2 in), 3–5 mm (to 0.2 in) in diameter. **Male cones** solitary, erect, ovoid, 13–17 cm (5.1–6.7 in) long, 7–9 cm (2.8–3.5 in) in diameter, densely orange tomentose. Sporophylls 33–40 mm (1.3–1.6 in) long. Sporophyll face 3–5 mm (to 0.2 in) high, 12–16 mm (0.5–0.6 in) wide, not curved backward and downward, apical spine sharply upturned, 10–15 mm (0.4–0.6 in) long, slender. Sporangia in a single patch covering the underside of the sporophyll. **Habitat:** Low-elevation coastal plain in savanna woodland, often in more open and grassy areas. The habitat is subjected to annual grass fires. **Distribution:** Papua New Guinea, southeastern part of the country, extending from Kairuku, Yule Island, southeast to Abau, and especially the coastal plain around Port Moresby.

Cycas campestris, in contrast to *C. schumanniana,* occurs only at low elevations along Papua New Guinea's southeastern coastal plain. It can be distinguished from the latter species by its short leaves with short stiff leaflets, and its broad lamina with numerous lateral spines.

I am not aware of any living material, other than seedlings, of *Cycas campestris* in cultivation, either in public or private gardens. Since most of the tropical *Cycas* species are fast growing and undemanding in cultivation, there is no reason to believe that *C. campestris* should respond differently. Although I would not recommend *C. campestris* for use in areas other than those with tropical to subtropical climates, as experience with its cultivation is gained we may find it will grow in temperate climates as well. Its small size would make it a welcome and decorative addition to the cultivated species of *Cycas.*

The conservation status of *Cycas campestris* is reported as secure because it is a common plant in many parts of its habitat. Distribution is sporadic, but the cycad is locally abundant. Seed has become available, so this cycad may become firmly established horticulturally, too.

Cycas canalis K. D. Hill 1994c

PLATE 107

The epithet for *Cycas canalis* is Latin for canal or channel, referring to this cycad's occurrence at Channel Point, Northern Territory, Australia. Two subspecies of *C. canalis* are recognized: *canalis* (described here) and *carinata.* **Stems** usually unbranched, to 3 m (10 ft) tall, rarely as tall as 5 m (16 ft), 7–13 cm (2.8–5.1 in) in diameter. Cataphylls densely orange tomentose, 7–9 cm (2.8–3.5 in) long. LEAVES numerous, strongly glaucous when new, becoming glossy medium to deep green with age, 60–90 cm (24–36 in) long, flat. Petiole glabrous or loosely orange tomentose, 15–25 cm (6–10 in) long, armed over its entire length. Leaflets in 50–85 pairs, angled forward 50–90°, flat, not crowded or overlapping, median leaflets 10–19 cm (4–7.5 in) long, 5–8 mm (0.2–0.3 in) wide, midrib slightly raised above, prominent below, margin flat and entire, decurrent at the base. FEMALE CONES open type. Sporophylls pendent when mature, 16–22 cm (6.3–8.7 in) long, gray and orange tomentose, each with two to four ovules. Lamina triangular, 40–60 mm (1.6–2.4 in) long, 22–32 mm (0.9–1.3 in) wide, regularly toothed, apical spine 2–3 cm (0.8–1.2 in) long. Sarcotesta orange when mature, not glaucous. Sclerotesta flattened ovoid, 3–4 cm (1.2–1.6 in) long, 3–3.6 cm (1.2–1.4 in) in diameter. MALE CONES solitary, ovoid, 15–22 cm (6–8.7 in) long, 8–11 cm (3.2–4.3 in) in diameter, finely orange tomentose. Peduncle short, cone appearing sessile. Sporophylls 28–32 mm (1.1–1.3 in) long. Sporophyll face 17–23 mm (0.7–0.9 in) wide, apical spine erect, 14–18 mm (0.6–0.7 in) long. HABITAT: Flat, well-drained soil in *Eucalyptus* woodland in coastal areas. Rainfall averages 1200–1600 mm (47–63 in) annually, falling mainly in summer. Temperatures are in the range 24–33°C (75–91°F) in summer, 18–30°C (64–86°F) in winter. DISTRIBUTION: Australia, Northern Territory, from Channel Point to the mouth of the Daly River, also reported from south of the Daly River but not confirmed.

Cycas canalis subsp. *canalis* has been described too recently for sufficient information to be available on its cultivation. This subspecies has a nice appearance and may make a good garden or landscape plant once it has been tested in cultivation.

The conservation status of *Cycas canalis* subsp. *canalis* is questionable. It is locally abundant but the total range is poorly known and relatively small.

Cycas canalis **subsp.** ***carinata*** K. D. Hill 1994c

The subspecific epithet for *Cycas canalis* subsp. *carinata* is derived from *carina,* Latin for keel, referring to the keeled rather than flat leaves. STEMS usually unbranched, erect, 2–5 m (6.6–16 ft) tall, 8–14 cm (3.2–5.5 in) in diameter. LEAVES numerous, straight, 0.7–1.1 m (2.3–3.6 ft) long, openly keeled, strongly glaucous when new, then green with age. Petiole glabrous, 15–25 cm (6–10 in) long, armed. Leaflets in 50–85 pairs, angled forward 40–50°, flat, median leaflets 12.5–20.5 cm (5–8.1 in) long, 5–8 mm (0.2–0.3 in) wide. FEMALE CONES open type. Sporophylls pendent when mature, 16–24 cm (6.3–10 in) long, densely orange tomentose, each with two ovules. Lamina triangular, 45–55 mm (1.8–2.2 in) long, 22–25 mm (0.9–1 in) wide, regularly toothed, apical spine about 1 cm (0.4 in) long. MALE CONES solitary, erect, ovoid, 15–20 cm (6–8 in) long, 11–12 cm (4.3–4.7 in) in diameter, densely orange tomentose. Sporophylls about 28 mm (1.1 in) long. Sporophyll face about 15 mm (0.6 in) wide, projecting about 12 mm (0.5 in), apical spine upturned, about 11 mm (0.4 in) long, stout. HABITAT: Usually lateritic soils in open forest or woodland. Rainfall averages 800–1200 mm (31–47 in) annually. Temperatures are in the range 24–36°C (75–97°F) in summer, 12–30°C (54–86°F) in winter. DISTRIBUTION: Australia, Northern Territory, scattered colonies in the Dorisvale district.

There is not a great deal of information available on the small blue *Cycas canalis* subsp. *carinata,* a cycad first brought into cultivation in 1992 and described in 1994. It has been known by the name Dorisvale blue in some seed catalogs. Cultivation should be similar to that for *Cycas conferta* and *C. pruinosa. Cycas canalis* subsp. *carinata* is a very pretty cycad and will no doubt become popular when it becomes more commonly available.

Cycas canalis subsp. *carinata* is not considered at risk. The colonies are large though sporadic, scattered over a large geographical area.

Cycas chamaoensis K. D. Hill 1999b

PLATE 108

The epithet for *Cycas chamaoensis* refers to the mountain Khao Chamao, the only known habitat of this cycad. STEMS arborescent, erect or decumbent, to 10 m (33 ft) tall. LEAVES numerous, sometimes more than 60, semi-glossy, deep green to gray-green, 1.2–2.5 m (3.9–8.2 ft) long, usually terminated by a spine 7–33 mm (0.3–1.3 in) long. Petiole 30–60 cm (12–24 in) long, glabrous, spiny 0–30% of its length. Leaflets in 85–155 pairs, lanceolate, glabrous, much lighter below than above, angled forward 60–70°, flat, spaced 9–14 mm (0.4–0.6 in) apart, basal leaflets 6–14 cm (2.4–5.5 in) long, not reduced to spines, median leaflets 16–30 cm (6.3–12 in) long, 7–11 mm (0.3–0.4 in) wide, midrib raised above and below, margins curved slightly backward and downward, the lower one decurrent for 4–9 mm (to 0.4 in). FEMALE CONES closed type. Sporophylls 13–18 cm (5.1–7.1 in) long, yellow to gray tomentose, each with two to four glabrous ovules. Lamina nearly circular, 6–9 cm (2.4–3.5

in) long and wide, deeply pectinate, with 30–40 soft lateral spines 2–3 cm (0.8–1.2 in) long, 3–6 mm (to 0.2 in) wide at the base. Sarcotesta about 3 mm thick, yellow when ripe, fibrous layer present. Sclerotesta smooth. Male cones solitary, erect, narrowly ovoid to spindle shaped, 50–60 cm (20–24 in) long, 12–13 cm (4.7–5.1 in) in diameter, orange. Sporophylls 41–55 mm (1.6–2.2 in) long. Sporophyll face 25–30 mm (1–1.2 in) wide, projecting 6–9 mm (0.2–0.4 in), apical spine prominent, sharply upturned, 4–12 mm (to 0.5 in) long. Habitat: Crevices in bare granite outcrops, generally in full sun. Distribution: Thailand, known only from the mountain Khao Chamao, northeast of Klaeng and southeast of Bangkok in eastern central Thailand.

It appears that the first botanical collection made of *Cycas chamaoensis* was in 1987, but it was not recognized as an undescribed species until the early 1990s. *Cycas chamaoensis* is a handsome plant that appears to be a vigorous grower even in its dry and harsh habitat. It is popular with local inhabitants, and many specimens are used in gardens in the surrounding countryside.

Apparently, the closest relative of *Cycas chamaoensis* is *C. pectinata.* It can be distinguished from *C. pectinata* by its narrower male cones with their much reduced apical spines on the sporophylls. In other respects, *C. chamaoensis* is quite similar to *C. pectinata,* and in the absence of cones it might be difficult to distinguish between them. I have found the seedlings of *C. chamaoensis* to be quite different from those of *C. pectinata,* with longer, more leathery leaflets and a much stronger seedling in general.

The only experience I have with cultivation of *Cycas chamaoensis* is represented by several 2-year-old seedlings I am raising. Their growth has been rapid, and they are very robust, indicating that *C. chamaoensis* will take well to cultivation. The only question is how cold hardy the cycad will prove to be. We can predict that *C. chamaoensis* will prove to be an exceptional cycad for tropical and subtropical climates.

The conservation status of *Cycas chamaoensis* is not good. It is apparently restricted to the mountain Khao Chamao and is under severe pressure from local plant collectors. Populations may still be numerous, but continued collecting must eventually take its toll. *Cycas chamaoensis* must be considered threatened.

Cycas chamberlainii W. H. Brown & Kienholz 1925

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Cycas chamberlainii is named in honor of Charles Joseph Chamberlain (1863–1943), author of *The Living Cycads,* for his contributions to the knowledge of cycads. Stems slender, arborescent, usually unbranched, 1–8 m (3.3–26 ft) tall, 10–20 cm (4–8 in) in diameter. Leaves numerous, arching, 1.2–1.6 m (3.9–5.2 ft) long, 40–55 cm (16–22 in) wide, glabrous or almost glabrous with age, sometimes with sparse brown hair persistent on the underside of the leaflets, especially along the midrib and along the sides of the rachis, emergent leaves densely brown hairy on lower rachis, less so toward the apex. Petiole 20–45 cm (8–18 in) long, armed with marginal spines about 3 mm long. Rachis subterete, somewhat flattened above and slightly grooved along the lines of the insertion of the leaflets. Leaflets in 80–95 pairs, opposite to alternate, angled slightly forward, slightly falcate, gradually acuminate to a sharp apex, median leaflets 20–30 cm (8–12 in) long, 9–11 mm (0.4 in) wide, margin flat in living material but revolute when dried, decurrent at the base to the next leaflet. Female cones closed type. Sporophylls 15–22 cm (6–8.7 in) long, densely brown tomentose, each with four to usually six ovules crowded below the lamina, inserted 1.8–3 cm (0.7–1.2 in) apart, glabrous, flattened obovoid. Lamina broadly subdeltoid to ovate, usually curved upward from the four- to six-angled and flattened stalk so as to be almost perpendicular to it, 3.5–5 cm (1.4–2 in) wide, with 4–10 spinelike divisions averaging 15–17 mm (0.6–0.7 in) long on each side, terminal spine 20–40 mm (0.8–1.6 in) long. Sarcotesta orange when ripe. Sclerotesta 32–38 mm (1.3–1.5 in) long, 23–25 mm (0.9–1 in) in diameter, long ovoid, pointed at the chalazal end, the surface with numerous short and indistinct longitudinal ridges. Male cones solitary, ovoid, about 13 cm (5.1 in) long and 8 cm (3.2 in) in diameter in a submature cone, rounded at apex. Sporophylls 33 mm (1.3 in) long. Sporophyll face 16–20 mm (0.6–0.8 in) wide, densely brown tomentose, the upper edge continued into an erect slender spine about 1 cm (0.4 in) long. Habitat: Steep and rocky cliffs and ridges in forest at elevations of 615–800 m (2000–2600 ft). Rainfall is moderate throughout the year, and the habitat is moist and cool. Distribution: Philippines, Luzon, Pampanga province, restricted to Mount Arayat.

Cycas chamberlainii, so far as I am aware, is very rare in collections. William Henry Brown and Raymond Kienholz, who described *C. chamberlainii,* gave the type locality as Mount Arayat, an isolated volcanic cone rising out of the great central plain of Luzon to 1830 m (6000 ft). It is possible that this isolation has kept *C. chamberlainii* from spreading to other parts of the island. *Cycas* is reasonably common on Luzon, and coastal areas are inhabited by *C. riuminiana,* a species that previously had been misidentified as either *C. circinalis* or *C. rumphii. Cycas chamberlainii* has small seeds without the flotation pad that characterizes *C. riuminiana* and a slender trunk as narrow as 10 cm (4 in) in diameter in sexually mature plants. The slender dimensions of the trunk make it easily distinguishable from the other Luzon *Cycas* species, whose trunk diameter is at least twice that of *C. chamberlainii.* It is quite easy to separate *C. chamberlainii* from the other three species known from the Philippines on the basis of the seeds alone. Both *C. curranii* and *C. wadei* have globose seeds with prominent longitudinal ridges, and *C. riuminiana* has larger seeds containing a flotation pad.

The Philippines cover a huge area and contain a bewildering number of islands. A great deal of endemism occurs because of the separation of the islands and the variety of habitats that have developed upon them. This endemism must surely extend to the genus *Cycas,* encountered on almost all the larger islands and many of the smaller ones. Yet only four species have been named from the Philippines, *C. chamberlainii, C. curranii, C. riuminiana,* and *C. wadei.* These four species are quite distinct and there is no question as to their validity. The numerous other colonies of Philippine *Cycas* have been misidentified as either *C. circinalis* or *C. rumphii.* I have no doubt that additional species will be described from these islands when the necessary fieldwork can be undertaken.

Cycas chamberlainii grows rapidly in cultivation and demands no special treatment. Cold tolerance is extremely high for a cycad from such a tropical habitat. Plants in my collection have withstood several degrees of frost without apparent damage. Damage does occur if freezing weather is encountered during the emergence of new leaves. The emergent leaves are destroyed or damaged to the extent that they do not develop to full size.

The conservation status of *Cycas chamberlainii* is not good. I received information in 1998 from Mark Cua of Manila, indicating that *C. chamberlainii* has been almost eradicated on Mount Arayat. Apparently, most of the remaining mature plants are systematically decapitated for landscaping material (Plate 26). Therefore, almost no regeneration is taking place. Only a few seedlings were observed plus a small number of mature plants that had been spared because they grew on inaccessible cliffs. The information available indicates that *C. chamberlainii* must be considered extremely endangered, nearing extinction in its habitat.

Cycas changjiangensis N. Liu 1998

The epithet for *Cycas changjiangensis* refers to Changjiang county on the western side of the island and province of Hainan, China. **Stems** subterranean or short arborescent, cylindrical, to 50 cm (20 in) long, 10–15 cm (4–6 in) in diameter, base swollen. Cataphylls deltoid lanceolate, 4–7 cm (1.6–2.8 in) long, about 1 cm (0.4 in) wide, densely tomentose, apex long acuminate. **Leaves** numerous, spreading, median green, 0.5–1.3 m (1.6–4.3 ft) long, 25–40 cm (10–16 in) wide. Petiole 10–30 cm (4–12 in) long, base densely yellow brown tomentose, usually armed with 8–16 spines 2 mm long. Leaflets usually in 20–35 pairs, leathery, linear, apex drawn out, base narrowed and lightly decurrent, median leaflets 10–17 cm (4–6.7 in) long, 4–7 mm (to 0.3 in) wide, midrib elevated above, margin flat or lightly revolute. **Female cones** closed type. Sporophylls 8–13 cm (3.2–5.1 in) long, densely tomentose, each with two to four ovules, pollination occurring April–May, seeds ripening October–November. Lamina ovate, about 5 cm (2 in) long, 4–8 cm (1.6–3.2 in) wide, densely tomentose, with 8–15 linear lanceolate lateral segments 2–3 cm (0.8–1.2 in) long, terminal segment 1–2 cm (0.4–0.8 in) long and producing two or three marginal lobes. Sarcotesta yellowish brown when dry. Sclerotesta broadly ovoid to subglobose, about 2 cm (0.8 in) in diameter. **Male cones** solitary, conical to cylindrical, 15–23 cm (6–9 in) long, 4–6 cm (1.6–2.4 in) in diameter, densely yellow brown tomentose. Peduncle 5–15 mm (0.2–0.6 in) long, densely velvety brown. Sporophylls wedge shaped, 15–20 mm (0.6–0.8 in) long. Sporophyll face 5–9 mm (0.2–0.4 in) wide, apical extension 1–2 mm long. Sporangia in a single irregular patch. **Habitat:** Grass-covered hills and seasonally dry woodland on deep sandy soils, at elevations of 800–900 m (2600–3000 ft). **Distribution:** China, island and province of Hainan, Changjiang county.

Cycas changjiangensis is a dwarf species native to western Hainan, situated off the southern coast of China. The species was described in 1998, and the author felt it is most closely related to *C. siamensis,* no doubt because of the enlarged base of the stem, which is typical of *C. siamensis.*

Because of its small size, *Cycas changjiangensis* is popular as a pot and garden plant. It seems to have no problem in cultivation as long as it is given well-drained soil and occasional feeding. I am not aware of any specimens of *C. changjiangensis* in the United States, Australia, or Europe, and thus have no cultivation data available.

The conservation status of *Cycas changjiangensis* is not well documented. There are still some large populations in the wild, probably because their natural habitat is not good agricultural land. On the other hand, some populations have been severely damaged as a result of construction. The overall reduction in this cycad's habitat in more recent years indicates that it should be considered threatened.

Cycas chevalieri Leandri 1931

PLATE 110

Cycas chevalieri, named in honor of Auguste Jean Baptiste Chevalier (1873–1956), French botanist and explorer who did research in Vietnam, is called *cáy ngen* (Vietnamese). STEMS subterranean, globose, 10–20 cm (4–8 in) in diameter. Cataphylls narrowly triangular, soft, woolly, 4–6 cm (1.6–2.4 in) long, persistent. LEAVES usually 5–20, very glossy deep green, 1.5–3 m (4.9–10 ft) long, flat to slightly keeled, emergent leaves orange tomentose, soon becoming glabrous. Petiole 20–70 cm (8–28 in) long, glabrous, spiny 60–100% of its length. Rachis rounded below, triangular above. Leaflets in 50–75 pairs, lanceolate, much lighter below than above, spaced 1–3 cm (0.4–1.2 in) apart, flat, apex soft, median leaflets 20–38 cm (8–15 in) long, 12–25 mm (0.5–1 in) wide, linear lanceolate, often slightly falcate, angled forward 40–75°, glabrous, constricted at their base, midrib prominent above, flat below, margin straight or undulate. FEMALE CONES closed type. Sporophylls 8–13 cm (3.2–5.1 in) long, the stalk 3–5 cm (1.2–2 in) long, 3–5 mm (to 0.2 in) in diameter, densely brown tomentose, each with two to four glabrous ovules. Lamina oval, 35–55 mm (1.4–2.2 in) long, 25–50 mm (1–2 in) wide, margin deeply pectinate, with 15–25 soft lateral spines 20–35 mm (0.8–1.4 in) long, apical spine distinct or not distinct, 25–40 mm (1–1.6 in) long, 3 mm wide, sometimes forked. Sarcotesta yellow when ripe. Sclerotesta ovoid, rough and warty, 18–27 mm (0.7–1.1 in) long, 15–25 mm (0.6–1 in) in diameter. MALE CONES solitary, erect, spindle shaped, 15–25 cm (6–10 in) long, 4–7 cm (1.6–2.8 in) in diameter, brown or cream tomentose. Sporophylls 14–17 mm (0.6–0.7 in) long. Sporophyll face 7–10 mm (0.3–0.4 in) wide, apical spine absent. HABITAT: Sheltered sites in primary forest on steep granite outcrops. DISTRIBUTION: Vietnam, western Tonkin province and Nghé-an province, said to be from Nghia Dàn (Nghia Hung) to Tram-lui, generally in the region south of Hanoi, especially southwest of Vinh near the border with Laos.

Cycas chevalieri, like so many Asian cycads, is not well known or documented. Reported from northern Vietnam early in the twentieth century, it has rarely been in evidence outside Vietnam since. The information regarding its morphology is sparse and has been incomplete, making identification of specimens very difficult. The relationship of *C. chevalieri* to *C. balansae* is not completely understood. It is hoped that more complete information about the morphology, range, and habitat of *C. chevalieri* will come to light.

To my knowledge there is no information available as to the cultivation requirements of *Cycas chevalieri.* It would be safe to assume that it requires a tropical to subtropical climate and a bright exposure for best results. In any case, cultivation remains a moot question as there have rarely been plants of *C. chevalieri* available outside Vietnam.

Although *Cycas chevalieri* has been extensively exploited for the ornamental plant trade in Hanoi, large populations remain in relatively inaccessible areas. Thus *C. chevalieri* is not considered to be at risk.

Cycas circinalis Linnaeus 1753

PLATE 111

Cycas undulata Desfontaines ex Gaudichaud-Beaupré 1829, *C. circinalis* f. *undulata* (Desfontaines ex Gaudichaud-Beaupré) J. Schuster 1932, *C. rumphii* f. *undulata* (Desfontaines ex Gaudichaud-Beaupré) Kanehira 1938

Cycas wallichii Miquel 1842

Zamia tonkinensis Linden & Rodigas 1885, *Cycas tonkinensis* (Linden & Rodigas) Linden & Rodigas 1886, *Epicycas tonkinensis* (Linden & Rodigas) de Laubenfels in de Laubenfels & Adema 1998

Cycas circinalis, the epithet from *circinalis,* Latin for coiled and referring to the circinate pattern of leaflet unfolding, is called queen sago, *varaguna* in Indian Sanskrit, *fangli-madan-mast-ka-phul* in Hindi, *mundicalu* in Kanarese, *intalappana* and *todda panna* in Malayan, *canningay* and *madana-gama* in Tamil, *per ita* and *kamkshi* in Telugu, and *orguna* and *odasa-mari* in Uriya. STEMS arborescent, erect, sometimes branched, 4–7 m (13–23 ft) tall, 25–40 cm (10–16 in) in diameter, old leaf bases usually prominent but sometimes weathering away to a more or less smooth skin. LEAVES usually 15–20, 1.5–3 m (4.9–10 ft) long. Petiole 50–70 cm (20–28 in) long, rounded below and slightly triangular above, armed on both sides by sharply deflexed spines 2–3 mm long. Leaflets in 90–120 pairs, linear lanceolate, straight to subfalcate, median leaflets 20–30 cm (8–12 in) long, 9–13 mm (0.4–0.5 in) wide, margin flat or scarcely revolute. FEMALE CONES open type. Sporophylls 15–30 cm (6–12 in) long, densely brown tomentose, each with 6–12 ovules. Lamina rhomboid, about 70 mm (2.8 in) long, 25–35 mm (1–1.4 in) wide, margin with narrow sharp teeth in the upper half, smooth in the lower half. Sarcotesta pale reddish yellow. Sclerotesta globose to ovoid, light tan, 30–35 mm (1.2–1.4 in) long, 27–30 mm (1.1–1.2 in) in diameter, the surface minutely fibrous. **Male cones** solitary, cylindrical ovoid, 60–70 cm (24–28 in) long, 15–18 cm (6–7.1 in) in diameter, tapering toward the apex, yellowish brown tomentose. Sporophylls 37–50 mm (1.5–2 in) long. Sporophyll face 12–19 mm (0.5–0.7 in) wide, apex forming an upcurved, narrow, drawn-out spine about 25 mm (1 in) long. **Habitat:** More or less dry deciduous forests on rocky ground at elevations of about 1070 m (3500 ft). **Distribution:** India, Western Ghats from Malabar southward to the tip of peninsular India, continuing along the Eastern Ghats as far north as Orissa.

Cycas circinalis is the type species of the genus *Cycas,* described by Carl Linnaeus. The material on which the original description was based originated in India. The Indian plants are quite distinct from the multitude of *"C. circinalis"* specimens from throughout the South Pacific and Asia. *Cycas circinalis* has been a catchall into which almost any *Cycas* with long, broad leaves is placed.

Cycas circinalis may be separated from the South Pacific species by its distinctive seed. Most of the South Pacific *Cycas* have a flotation pad between the sclerotesta and female gametophyte, allowing the seed to float, doubtless an aid to distribution by ocean currents. Seeds from the South Pacific are generally quite large because of this flotation pad. Seeds of the Indian *C. circinalis* are quite small, about the size of the seed of *C. revoluta,* and do not contain a flotation pad. The surface of the sclerotesta is not smooth or lightly fissured as in the plants from the South Pacific, but minutely fibrous. A hand lens is necessary to observe these fine projections on the sclerotesta surface, which seem to be unique to *C. circinalis.*

As in numerous other species of *Cycas* from dry habitats, *C. circinalis* tends to be deciduous. Often, female plants in seed do not maintain a crown of leaves. This may also be an adjunct to the dispersal of the seeds, placing them in full view of predators when the sarcotesta ripens and turns yellow-orange.

Cycas circinalis is easy to grow from seed, rapidly developing into a sizable plant. The deciduous growth habit exhibited in the wild is generally lacking in cultivated plants, probably because of the constant availability of water and nutrients.

The conservation status of *Cycas circinalis* is not good. What was once a very common cycad has been greatly reduced in numbers through land clearance. Although it is not endangered, it must be considered severely threatened.

Cycas clivicola K. D. Hill 1999b

PLATES 112, 113

The epithet for *Cycas clivicola* is derived from *clivus,* Latin for slope of a hill, and *-cola,* inhabitant or dweller, referring to this cycad's habitat, usually on steep slopes or cliffs. Two subspecies of *C. clivicola* are recognized: *clivicola* (described here) and *lutea.* **Stems** arborescent, erect, to 8 m (26 ft) tall, 10–16 cm (4–6.3 in) in diameter, generally pale gray. **Leaves** numerous, semiglossy, bright to deep green, 0.7–1.7 m (2.3–5.6 ft) long, often terminated by a spine 2–15 mm (to 0.6 in) long. Petiole 15–55 cm (6–22 in) long, glabrous, armed with spines 10–80% of its length. Leaflets in 45–110 pairs, glabrous, slightly lighter green below, angled forward 45–70°, opposing leaflets inserted at an angle of 170–180° to each other, thus almost in the same plane, spaced 7–16 mm (0.3–0.6 in) apart, lower leaflets not gradually reduced to spines, median leaflets 9–22 cm (3.5–8.7 in) long, 5–9 mm (0.2–0.4 in) wide, midrib prominent above and below, margins flat to lightly revolute, the lower one decurrent for 3–9 mm (to 0.4 in). **Female cones** closed type. Sporophylls 12–22 cm (4.7–8.7 in) long, densely yellow to gray tomentose. Lamina nearly circular, 7–14 cm (2.8–5.5 in) long, 6–9.5 cm (2.4–3.7 in) wide, deeply pectinate, with 26–54 soft lateral spines 20–46 mm (0.8–1.8 in) long, 2–4 mm wide, apical spine distinct, 20–50 mm (0.8–2 in) long, 3–8 mm (to 0.3 in) wide at its base. Sarcotesta yellow when ripe, not glaucous, fibrous layer present. Sclerotesta 35–45 mm (1.4–1.8 in) long, 23–35 mm (0.9–1.4 in) in diameter, smooth, interior spongy layer absent. **Male cones** solitary, narrowly ovoid, 25–50 cm (10–20 in) long, 8–11 cm (3.2–4.3 in) in diameter, yellow to brown or green. Sporophylls 19–25 mm (0.7–1 in) long. Sporophyll face 10–15 mm (0.4–0.6 in) wide, apical spine prominent, sharply upturned or gradually raised, 5–16 mm (0.2–0.6 in) long. Sporangia in a single patch. **Habitat:** Common on vertical to nearly vertical limestone cliffs and outcrops, often rooted in cracks and crevices, sometimes with no soil at the roots, generally from sea level to about 60 m (200 ft). **Distribution:** Thailand, southern part of the country, and northern Malaysia, common on offshore islands.

Cycas clivicola was described in 1996 though the existence of this cycad had been known for many years, but misidentified as *C. siamensis.* It is quite distinct from *C. siamensis* with its smooth stems and small male cones with their small microsporophylls. The habitats of the two species are also quite different, with *C. siamensis* growing on relatively flat areas and *C. clivicola* almost always associated with steep to vertical limestone outcrops and cliffs. A number of the offshore islands of the Andaman Sea, with their limestone cliffs rising vertically to dizzying heights, provide homes for *C. clivicola.* Often, specimens of great age, with stems several meters (yards) long and whose roots can no longer maintain them in an upright position, hang from the cliffs, only the apex pointing skyward.

Cycas clivicola is not commonly cultivated in Thailand or Malaysia, or outside its native countries. In spite of little experience in the cultivation of *C. clivicola,* no problems are expected. Seedlings of *C. clivicola* have exhibited a slow growth rate but no other problems. Since limestone cliffs are the habitat of preference, one may expect the need for a planting mix with a basic pH and exceptional drainage. Full sun exposure would also be expected to be beneficial to the health of this cycad. In general, *Cycas* exhibits good cold tolerance, even in the tropical species, so short periods of near-freezing temperatures should not be expected to be overly dangerous to health of the plants.

The conservation status of *Cycas clivicola* subsp. *clivicola* is encouraging. It is widespread and abundant in typically inaccessible sites and therefore is not considered threatened.

Cycas clivicola **subsp.** ***lutea*** K. D. Hill 1999b

PLATE 114

The subspecific epithet for *Cycas clivicola* subsp. *lutea* is derived from *luteus,* Latin for yellow, referring to the yellowish stems. **Stems** arborescent, erect, to 6 m (20 ft) tall, 10–14 cm (4–5.5 in) in diameter, yellowish, smooth. **Leaves** numerous, semiglossy bright green, 0.9–1.6 m (3–5.2 ft) long, flat, usually terminated by a spine 2–6 mm (to 0.2 in) long. Petiole 20–45 cm (8–18 in) long, glabrous, spiny 15–70% of its length. Leaflets in 130–200 pairs, lanceolate, glabrous, not much lighter below than above, angled forward 65–80°, basal leaflets 5–7.5 cm (2–3 in) long, not reduced to spines, median leaflets spaced 8–14 mm (0.3–0.6 in) apart, 10–26 cm (4–10 in) long, 5–9 mm (0.2–0.4 in) wide, midrib raised above and below, margins flat and straight, the lower one decurrent for 5–8 mm (0.2–0.3 in). **Female cones** closed type. Sporophylls 10–20 cm (4–8 in) long, densely yellow-brown tomentose, each with one to three ovules. Lamina 5–10 cm (2–3.9 in) long, 4–7 cm (1.6–2.8 in) wide, deeply pectinate, with 20–36 soft lateral spines 18–35 mm (0.7–1.4 in) long, 2–4 mm wide, apical spine distinct, 20–40 mm (0.8–1.6 in) long, 3–5 mm (to 0.2 in) wide at its base. Sarcotesta orange when ripe. Sclerotesta 33–37 mm (1.3–1.5 in) long, 26–33 mm (1–1.3 in) in diameter. **Male cones** solitary, erect, narrowly ovoid, 20–25 cm (8–10 in) long, 8–9 cm (3.2–3.5 in) in diameter, densely yellow to brown tomentose. Sporophylls 28–33 mm (1.1–1.3 in) long. Sporophyll face 17–19 mm (0.7–0.8 in) wide, projecting about 6 mm (0.2 in), apical spine prominent, sharply upturned, 5–8 mm (0.2–0.3 in) long. Sporangia in a single patch. **Habitat:** Limestone outcrops and cliffs in full sun. **Distribution:** Thailand, on the mainland in the extreme southeastern area, southeast of Bangkok, between Klaeng and Ban Nam Sae, north to Aranyapraphet on the Cambodian border, also ranging into adjacent Cambodia, where it has been collected between Batdâmbâng and Sisöphön. Vietnam, collected at Hà Tiên.

In 1992 I investigated what was to become *Cycas clivicola* subsp. *lutea.* The cycads were grand, growing on the vertical sides and tops of some of the limestone hills southwest of Aranyaprathet, Thailand. There were numerous large plants in evidence, and their handsome stems and leaves impressed me. I was also struck by the view of the surrounding countryside, laid out far below as if we were in an airplane. All of the surrounding flatlands several hundred feet below were under cultivation but seemed far removed from our lofty vantage point. The cycads were growing in small pockets of earth collected in crevices in the deeply fissured limestone cliffs, where they were exposed to the wind and blazing tropical sun.

Cycas clivicola subsp. *lutea* is a handsome cycad with its bluish leaves and yellowish stems. It is admired by the local populace and its use as a garden plant is not uncommon. In 1996 a quantity of seed of what is subspecies *lutea* was exported from Thailand to several countries, including the United States and Australia. It is hoped that this seed will establish subspecies *lutea* in cultivation and assure its continued existence outside Thailand. It is too soon to determine how well subspecies *lutea* will fare in a temperate Mediterranean (winter rainfall) climate. If it adjusts well, it would make a fine addition to the landscape of southern California and other areas with a similar climate.

Cycas clivicola subsp. *lutea* differs from subspecies *clivicola,* which has larger male cones with longer and broader sporophylls. It somewhat resembles *C. pectinata* in that both have a smooth yellowish stem whereas *C. clivicola* subsp. *clivicola* generally has a gray stem.

The conservation status of *Cycas clivicola* subsp. *lutea* appears to be secure. Although under severe pressure from plant collectors in some areas, this subspecies is still found in large numbers in some extremely inaccessible sites. For these reasons it can be considered not threatened.

Cycas collina K. D. Hill, H. T. Nguyen & L. K. Phan in Hill et al. 2002

PLATE 115

The epithet for *Cycas collina* is derived from *collinus*, Latin and pertaining to hills, referring to this cycad's occurrence in the high ridge country of northern Vietnam. **Stems** procumbent or subterranean, 15–80 cm (6–31 in) long, 8–13 cm (3–5 in) in diameter. Cataphylls narrowly triangular, soft, lightly tomentose, 5–8 cm (2–3.2 in) long, persistent. **Leaves** generally two to five, semiglossy deep green, 1.4–3.3 m (4.6–11 ft) long, slightly keeled, emergent leaves densely orange tomentose, becoming glabrous as leaf matures. Petiole glabrous, 0.7–1.9 m (2.3–6.2 ft) long, spiny 90–100% of its length. Rachis generally terminated with paired leaflets. Leaflets in 60–90 pairs, much lighter below than above, angled forward 80–85°, flat or slightly keeled, basal leaflets not gradually reduced to spines and generally 20–26 cm (8–10 in) long, median leaflets 28–41 cm (11–16 in) long, 17–23 mm (0.7–0.9 in) wide, spaced 17–25 mm (0.7–1 in) apart, midrib raised above and below, margin flat or undulate, decurrent for 2–5 mm (to 0.2 in). **Female cones** closed type. Sporophylls 10–14 cm (4–5.5 in) long, densely yellow tomentose, each with two to four glabrous ovules. Lamina ovate, about 6 cm (2.4 in) long and 3 cm (1.2 in) wide, deeply pectinate, with 12 soft lateral spines about 3 cm (1.2 in) long, to 2 mm wide, apical spine not distinct. Sarcotesta yellow. Sclerotesta 25–27 mm (1–1.1 in) long, 18–21 mm (0.7–0.8 in) in diameter, the surface lightly warty. **Male cones** solitary, narrowly ovoid or spindle shaped, 25–35 cm (10–14 in) long, 7–9 cm (2.8–3.6 in) in diameter, cream yellow. Sporophylls 12–14 mm (0.5–0.6 in) long. Sporophyll face 8–10 mm (0.3–0.4 in) wide, without an apical spine. **Habitat:** Evergreen or partially deciduous forests, woodlands, or bamboo thickets on steep slopes of mountain ridges at elevations above 500 m (1600 ft), in soils varying from red clay on limestone to loamy soils on sediments. **Distribution:** Vietnam, northern part of the country, mainly Sòn La province, also expected to occur in Laos.

Cycas collina is one of the more recently described cycads from Vietnam, generally occurring on steep slopes above 500 m (1600 ft) in evergreen or partly deciduous forests or woodlands. Although this species does not occur in dense stands, it is widespread and not uncommon. The distinguishing features of *C. collina* are basically its few, long leaves with widely spaced leaflets, and large male cones with rounded sporophyll faces without an apical spine.

Cycas collina is evidently not particularly handsome, and for this reason it is not widely grown in Vietnam. Generally, the cycads most sought after are those with short leaves, not species such as *C. collina* with very long leaves. This cycad might make an interesting garden plant if sufficient space is available. It will no doubt require tropical to subtropical conditions and sufficient shade.

The conservation status of *Cycas collina* appears to be good. It is widespread, and though it does not occur in large or dense populations, it is reasonably common within its distributional range. Its habitat is being reduced as a result of land clearance for agriculture, however, yet many populations remain untouched.

Cycas condaoensis K. D. Hill & S. L. Yang in Hill et al. 2002

PLATE 116

The epithet for *Cycas condaoensis* refers to the Con Dao Islands, Vietnam, where this cycad occurs. **Stems** arborescent, erect, 0.2–2.5 m (0.6–8.2 ft) long, 14–17 cm (5.5–6.7 in) in diameter, base prominently swollen. Cataphylls narrowly triangular, pungent, lightly tomentose to glabrous, 5–6 cm (2–2.4 in) long, persistent. **Leaves** generally 12–70 in a crown, semiglossy bright green, 0.7–1.8 m (2.3–5.9 ft) long, flat, emergent leaves densely white or brown tomentose, soon becoming glabrous, apex generally terminated by paired leaflets. Petiole 20–50 cm (8–20 in) long, glabrous, spiny 0–60% of its length. Leaflets in 65–130 pairs, much lighter below than above, angled forward 60–75°, apex acute but not spiny, basal leaflets not gradually reduced to spines, generally 2.5–12 cm (1–4.7 in) long, median leaflets 13–24 cm (5.1–9.5 in) long, 7–12 mm (0.3–0.5 in) wide, spaced 5–17 mm (0.2–0.7 in) apart, midrib raised above and below, margin lightly revolute, decurrent for 3–6 mm (to 0.2 in) **Female cones** closed type. Sporophylls 9–17 cm (3.6–6.7 in) long, densely yellow to pale brown tomentose, each with two to four glabrous ovules. Lamina broad lanceolate, 6–12 cm (2.4–4.7 in) long, 3.5–5.5 cm (1.4–2.2 in) wide, margin deeply pectinate, with 20–32 soft lateral spines 8–18 mm (0.3–0.7 in) long, 1.5–2 mm wide, apical spine distinct, 2.5–6 cm (1–2.4 in) long, 4–10 mm (to 0.4 in) wide at its base. Sarcotesta 4–6 mm (to 0.2 in) thick, orange to yellow, not glaucous, fibrous layer present. Sclerotesta smooth, 39–43 mm (1.5–1.7 in) long, 33–36 mm (1.3–1.4 in) in diameter, spongy endocarp absent. **Male cones** solitary, narrowly ovoid, 26–31 cm (10–12 in) long, 9–12 cm (3.6–4.7 in) in diameter, orange to brown. Sporophylls 3–5 cm (1.2–2 in) long, 1.2–2 cm (0.5–0.8 in) wide. Sporophyll face 7–11 mm (0.3–0.4 in) long, apical spine prominent, sharply upturned, 4–5 mm (0.2 in) long. **Habitat:** Dry, low, open shrubland to dense tall shrubland or woodland, either on beach dunes or windblown beach sand deposits. **Distribution:** Vietnam, extreme southern part of the country, only on the Con Dao Islands.

Cycas condaoensis is a more recently described species that has in the past been incorrectly identified as *C. pectinata* (Leandri 1931) and *C. inermis* (Hiep and Vidal 1996). Actually, *C. condaoensis* is somewhat intermediate between *C. siamensis* and the *C. pectinata* group in many of its characters. The small, narrowly ovoid male cones of *C. condaoensis* distinguish it from those the *C. pectinata* group, the male cones of which are broadly ovoid, and the glabrous leaves without basal leaflets reduced to spines separate it from *C. siamensis.*

Cycas condaoensis is a handsome cycad that because of its medium size and keeled leaves could become popular as a landscape plant. To my knowledge it has not been introduced into horticulture outside Vietnam. This plant would require semitropical to tropical climates and well-drained soil for best results. The conservation status of *Cycas condaoensis* is good, not considered to be at risk.

Cycas conferta Chirgwin 1993

PLATES 117, 118

The epithet for *Cycas conferta* is derived from *confertus,* Latin for crowded, referring to the closely spaced to overlapping leaflets. **Stems** erect, commonly branched as a result of injury, attaining a maximum height of 4.5 m (15 ft), 10–13 cm (4–5.1 in) in diameter, the underground portion of the stem swelling to almost twice the diameter of that above ground, old leaf scars persisting on younger portions of the stem, usually about 1 m (3.3 ft), older portions becoming somewhat smooth though at that stage shallow cracks crazing the surface, unburned stems more or less gray-brown. Cataphylls spinelike, 6–7 cm (2.4–2.8 in) long, persisting more than a year. **Leaves** usually 45–70 in a crown, dull sea green, straight, 0.6–1.1 m (2–3.6 ft) long, 15–20 cm (6–8 in) wide, slightly keeled, emergent leaves golden brown tomentose and glaucous green, the tomentum soon lost and the bloom disappearing during the first year. Petiole 25–35 cm (10–14 in) long, armed with spines from lower leaflets to the base in juvenile plants, partially armed in intermediate-aged plants, unarmed in adults. Leaflets in 60–95 pairs, linear lanceolate, curved somewhat forward and downward, crowded, gradually acuminate toward the apex, gradually becoming shorter at apex, abruptly shorter at base, median leaflets 9.4–10 cm (3.7–4 in) long, 5–9 mm (0.2–0.4 in) wide, midrib prominent above and below, lighter in color than the leaflets, margins entire and flat, the lower one decurrent but not much narrowed at its attachment. **Female cones** open type. Sporophylls 30–40, pendent when mature, 12–20 cm (4.7–8 in) long, densely red-brown tomentose, each with two to four glabrous ovules, rarely five or six. Lamina somewhat spade shaped, 45–75 mm (1.8–3 in) long, 18–30 mm (0.7–1.2 in) wide, margin entire or with a few poorly developed teeth but no marginal spines, drawn-out terminal spine 2–30 mm (to 1.2 in) long. Sarcotesta brownish orange to purple-brown when ripe. Sclerotesta ovoid, with an extended point at the chalaza, 3.5–4 cm (1.4–1.6 in) long, 2.5–3 cm (1–1.2 in) in diameter, light tan, the surface with a network of shallow grooves. **Male cones** solitary, erect, conical, 22.5–33 cm (9–13 in) long, 9–15 cm (3.5–6 in) in diameter, orange tomentose. Peduncle to 3.5 cm (1.4 in) long but hidden among the cataphylls and the cone often appearing sessile. Sporophylls 25–29 mm (1–1.1 in) long. Sporophyll face deltoid, 14–17 mm (0.6–0.7 in) wide, red-brown tomentose, the upper face extended into an erect apical spine 7–12 mm (0.3–0.5 in) long. **Habitat:** Flat plains or low granite hills in association with *Eucalyptus* and grasses, in light and fine soil or coarse decomposed granite. **Distribution:** Australia, Northern Territory, scattered small colonies from Kakadu National Park to west of the town of Pine Creek.

Cycas conferta is one of Australia's most beautiful species. Seed was originally distributed in the mid-1980s as *Cycas* "Pine Creek." By all accounts it is not common in its habitat, with a population estimated as about 300 individuals, and is found in small scattered colonies over a relatively large area. The most distinguishing characteristic of this cycad is its beautiful leaf color, a dark, dull, sometimes glaucous green. The leaves appear velvety and one is almost compelled to touch them to discover if they are as soft as they look. The small size, graceful form, and striking color combine to make this one of the most desirable and handsome of the Australian cycads.

The only other species of *Cycas* that comes into direct contact with *C. conferta* is *C. armstrongii.* Where the distributions of these two overlap, numerous hybrids have been observed.

The relatively recent discovery of *Cycas conferta* means that not much is known about its cultivation. There do not appear to be any major problems in its cultivation with the possible exception of the seedling stage. I have found it to be difficult to grow from seed because of its habit of developing crown rot. The plant's contractile roots, pulling the crown of the seedling into soil that is too damp, may cause this problem. The end product is a seedling with a perfectly healthy root but no crown. There is a possibility that this condition could also be caused by collecting seed before it is fully mature. Immature seed will often germinate, but the resultant seedlings appear to be weaker than those from fully ripened seed.

The conservation status of *Cycas conferta* does not appear to be secure. From the scant information available, I would say that this cycad is endangered. The few small populations that have been located are already under considerable pressure from plant collectors, and many plants have been removed. Because the populations are small, the seed crops are often harvested before they are fully ripe because of competition among seed collectors. We must hope that some of the populations of *C. conferta* will be included in parks or other areas that can be properly protected from unrestricted poaching.

Cycas couttsiana K. D. Hill 1992

PLATES 119, 120

Cycas couttsiana, named in honor of Pat and David Coutts, former leaseholders of Chudleigh Park station, Queensland, Australia, where this cycad was discovered and where they took steps to protect it in its habitat, is called Glen Idle blue. **Stems** arborescent, rarely branched, usually to 3 m (10 ft) tall, rarely as tall as 10 m (33 ft), 14–20 cm (5.5–8 in) in diameter, the portion of the stem below ground swollen in mature plants. **Leaves** numerous, glaucous, 1–1.3 m (3.3–4.3 ft) long, flattened width 22–37 cm (8.7–15 in), strongly keeled, emergent leaves densely gray-white tomentose, the tomentum persisting for some time on the rachis and the underside of the leaflets. Petiole 25–28 cm (10–11 in) long, persistently gray tomentose, lightly to heavily armed with straight or slightly downward angled spines 3 mm long. Leaflets in 90–135 pairs, lanceolate, strong glaucous blue, narrowed at the attachment to 3–4.5 mm, spaced 5–9 mm (0.2–0.4 in) apart, median leaflets 17–21 cm (6.7–8.3 in) long, 4.5–6 mm (0.2 in) wide, midrib not raised or only slightly above, prominent below, margins slightly revolute to almost flat, entire, the lower one decurrent for 2–5 mm (to 0.2 in). **Female cones** open type. Sporophylls 16–28 cm (6.3–11 in) long, at first densely reddish tomentose, with age almost glabrous except for the lower surface, each with three to six ovules, usually four, globose, glabrous, and glaucous. Lamina narrowly triangular, 4–6 cm (1.6–2.4 in) long, 2–3 cm (0.8–1.2 in) wide, regularly toothed, apical spine 1.5–2.5 cm (0.6–1 in) long. Sarcotesta orange to brown-orange when ripe with a heavily glaucous surface, causing the ripe seed to appear somewhat purplish. Sclerotesta ovoid, slightly flattened, 38–45 mm (1.5–1.8 in) long, 32–36 mm (1.3–1.4 in) in diameter, with a more or less smooth surface. **Male cones** solitary, somewhat ovoid, 15–20 cm (6–8 in) long, 8–10 cm (3.2–4 in) in diameter, densely light tan tomentose when young, older cones becoming glabrous. Peduncle very short, cone appearing sessile. Sporophyll face 12–15 mm (0.5–0.6 in) wide, projecting about 8 mm (0.3 in), apical spine upturned, about 8 mm (0.3 in) long. Sporangia in a single patch covering the entire underside of the sporophyll. **Habitat:** Steep canyons or flatlands in grassy, *Eucalyptus* woodland at elevations averaging 700 m (2300 ft) in red sandy loam soil. In some areas *Cycas couttsiana* is the dominant plant. Frost is not uncommon in winter. **Distribution:** Australia, Queensland, southern portion of the Gregory Range, in scattered large colonies.

I first became aware of *Cycas couttsiana,* then known as the Glen Idle blue, on my first trip to Australia in 1984. At that time it was only known to occur on the cattle station named Chudleigh Park. As luck would have it, I was introduced to the owners, Pat and David Coutts, during a Palm Society dinner in Townsville, Queensland. We discussed this cycad at length and I inquired if it would be possible to visit Chudleigh Park and study the plants in their habitat. I was told it could be arranged, but not for several days. Plans were made to meet them at the airport in Cairns, Queensland. I was informed that they had enough space on their plane to include two other people if I cared to invite them, and that we must plan at least 3 days for the trip. On the designated morning my traveling companions, Ed Moore of San Diego, California, and Stan Walkley of Brisbane, Australia, and I waited impatiently for the plane to arrive. When it did we were greeted by Pat and David, and soon boarded with all our equipment to begin the flight to Chudleigh Park. This was my first trip to the outback and I was amused to see cattle being run off the dirt runway so that we could land. The station manager and one of the hands met us with two four-wheel-drive trucks to carry us to the homestead. After a long and often bumpy ride, we settled into our rooms and were provided with a good meal.

The next morning, after an early breakfast, we set off on a rough 2-hour drive to the cycad habitat. During this drive we were able to see numerous native animals, including dingoes, kangaroos, wallaroos, sulfur crested and black palm cockatoos, and the giant ostrichlike emu to name but a few. *Cycas couttsiana* is a beautiful and graceful cycad with blue-gray leaves and tall, slender trunks. The seeds are large and when ripe can be seen from as much as 100 m (yards) away. We had a picnic lunch among the cycads, took photographs, collected herbarium specimens, and then started back to the homestead. All in all, it was one of the most enjoyable of my many trips in search of cycads.

Cycas couttsiana is now fairly common in Australian gardens. Seed germinates easily and the growth rate is fairly rapid after a good root system is established. The striking blue foliage is maintained in cultivation, and this cycad makes a fine addition to any garden. Frost is not uncommon in this cycad's habitat, and plants in cultivation have shown an exceptional tolerance to cold.

Pat and David Coutts have accomplished conservation of *Cycas couttsiana* by fencing off one stand of plants. The borders of the habitat are also kept free of grass to prevent fire from going through the cycads and destroying the seeds. Because of the remote habitat and the protection provided by the Coutts, *C. couttsiana* can be considered not threatened. Several other large stands of *C. couttsiana* have been located in steep canyons where fire is usually not a problem. The abundance of seed produced and prolific regeneration in habitat bode well for the future of this beautiful and interesting species.

Cycas curranii (J. Schuster) K. D. Hill 1995

PLATES 121, 122

Cycas circinalis var. *curranii* J. Schuster 1932

Cycas curranii is named in honor of Hugh McCullom Curran III (b. 1875), American botanist who worked as Forest Officer for the Bureau of Forestry in Manila, Philippines, 1906–1913, and discovered this cycad. **Stems** arborescent, erect, to 11 m (36 ft) tall, 30–60 cm (12–24 in) in diameter, the surface retaining the scars of fallen leaves. There are unconfirmed reports of much larger plants. **Leaves** numerous, spreading, approximately 1.8–2.5 m (5.9–8.2 ft) long, 53–57 cm (21–22 in) wide. Petiole to 50 cm (20 in) long and armed with short spines over its entire length. Leaflets straight to slightly falcate, set flat into the rachis, 26–28 cm (10–11 in) long, 11–13 mm (0.4–0.5 in) wide, margin flat, either straight or undulate. **Female cones** closed type. Sporophylls 20–25 cm (8–10 in) long, densely light brown tomentose, each with two to four ovules. Lamina 14.5–16.5 cm (5.7–6.5 in) long, narrowly triangular, margin with 11–14 spines 2–2.5 cm (0.8–1 in) long, apical spine 5–10 cm (2–3.9 in) long. Sarcotesta orange when ripe. Sclerotesta globose to ovoid, 40–48 mm (1.6–1.9 in) long, 37–47 mm (1.5–1.9 in) in diameter, dark brown, the surface with 14–19 prominent longitudinal ridges 1 mm high. **Male cones** solitary, erect, "large" (K. D. Hill), yellowish green. Sporophylls 55–57 mm (2.2 in) long when dry. Sporophyll face 4–7 mm (to 0.3 in) high, 28–33 mm (1.1–1.3 in) wide, apical spine erect, straight, 30–37 mm (1.2–1.5 in) long, 4–7 mm (to 0.3 in) wide. Sporangia in a somewhat heart-shaped patch covering most of the underside of the sporophyll. **Habitat:** Rain forest at low elevations. **Distribution:** Philippines, island of Palawan, in the catchment of the Malinao River.

Cycas curranii was discovered by Hugh McCullom Curran III on his first trip to Palawan in May 1906. His herbarium specimens were distributed to nine institutions in the Philippines, Europe, and the United States. For the next quarter century these specimens were all misidentified as *C. circinalis.* Julius Schuster's monograph on cycads was published in *Das Pflanzenreich* in 1932. In this treatment he described *C. circinalis* subsp. *riuminiana* var. *curranii,* based on one of the specimens collected by Curran. Kenneth D. Hill recognized *C. curranii* as specifically distinct and elevated it to the rank of species in 1995. *Cycas curranii* is a large, attractive cycad that produces one of the most distinctive seed sclerotestas of the genus. The large seeds with their distinctive raised ridges might only be mistaken for one other species, *C. wadei,* also from the Philippines. *Cycas wadei* is endemic to the island of Culion in the nearby Calamian Group. It, too, has distinctively ridged seeds, but the seeds are much smaller and the ridges are not as pronounced as those of *C. curranii.*

Not a great deal of information is available about the habit or habitat of *Cycas curranii.* It grows in remnants of virgin rain forest on Palawan and may be restricted to the catchment of the Malinao River, though reports of cycads in the watershed of Puerto Princesa, the provincial capital of Palawan, may also be this species. While inquiring for seed of this cycad I received a letter from a collector, "The plants [cycads] are as tall as trees with trunks as thick as those of big trees. The crown of these plants often reaches the canopy of the forest. Some plants have produced up to one thousand seeds each. The aborigines are taking care of these plants in the hope that there is money in them." These comments would lead me to believe that mature old plants might be considerably larger than the measurements I have available for this species.

I have had *Cycas curranii* in cultivation for somewhat more than 2 years. They are seedlings that have a stem diameter of 5–6 cm (2–2.4 in) and several leaves to 75 cm (30 in) tall. Some of the leaflets exhibit a distinctive undulating margin that is quite pleasing. Cold hardiness has not been tested as yet, but I would guess that this cycad could prove to be a fine ornamental in subtropical and tropical climates.

The conservation status of *Cycas curranii* is not well known. There has been much logging and land clearance in the habitat and this has reduced this cycad's distribution and numbers. On the bright side, if the natives try to protect these cycads for the money they can earn from gathering seeds, it can only help in their survival.

Cycas debaoensis Y. C. Zhong & C. J. Chen 1997

PLATES 123, 124

The epithet for *Cycas debaoensis* refers to the city of Debao, Guangxi autonomous region, China, near which this cycad was discovered. **Stems** subterranean or slightly emergent, globular, to 25 cm (10 in) in diameter. **Leaves** usually 7–11, arching, bipinnate, 1.5–3.5 m (4.9–12 ft) long, and about 1.3 m (4.3 ft) wide. Petiole about 1.2 m (3.9 ft) long. **Female cones** closed type. Sporophylls usually with four ovules each. Lamina more or less round, with 14–25 pairs of long, narrow segments. **Male cones** not described. **Habitat:** Seasonally dry, sunny, open slopes or cliffs covered with limestone boulders at an elevation of about 850 m (2800 ft). The original shrub and tree cover of the habitat has been almost completely removed. **Distribution:** China, Guangxi autonomous region, known only from near Debao.

Cycas debaoensis is a remarkable species, closely related to *C. multipinnata.* Like *C. multipinnata, C. debaoensis* has the extraordinary bipinnate leaf structure that immediately sets these two species apart from all other species of the genus. It is remarkable that a cycad as unusual as *C. debaoensis* was not described until 1997, but *C. multipinnata,* originally misidentified as *C. micholitzii,* was described as late as 1994. The discovery of these two unique cycads, *C. debaoensis* and *C. multipinnata,* at this late stage of the botanical exploration of China makes one wonder what other interesting species remain to be found.

The description of *Cycas debaoensis* was painfully concise and consisted of one small paragraph. Thus the description here lacks many measurements that are usually included, of leaves and cones, for example.

At the present time there is no information available as to the ease or difficulty of cultivation of *Cycas debaoensis.* It will no doubt take several years before such data become available. There is no reason to believe that *C. debaoensis* will be more difficult in cultivation than *C. multipinnata,* which has presented no major problems. Since the habitat of *C. debaoensis* is both higher and drier than that of *C. multipinnata,* we should expect it to be easier to cultivate in more temperate climates.

Cycas debaoensis can be considered as not threatened. A survey of the habitat in 1999 disclosed the presence of approximately 2000 plants of *C. debaoensis,* and regeneration is good. No evidence of plant removal was noted at the time of the survey, though that situation could change very rapidly.

Cycas desolata P. I. Forster 1995

PLATE 125

The epithet for *Cycas desolata* is Latin for ruinous or desolate, referring to this cycad's habitat. **Stems** erect, to 4 m (13 ft) tall, rarely as tall as 7 m (23 ft), 15–25 cm (6–10 in) in diameter. Cataphylls linear lanceolate, 3–4.5 cm (1.2–1.8 in) long, 2–4 mm wide, densely orange-brown tomentose at the base. **Leaves** numerous, erect, curved slightly backward and downward at the apex, glaucous blue, 0.8–1.2 m (2.6–3.9 ft) long, strongly keeled. Petiole glabrous, 10–23 cm (4–9.1 in) long, spines absent on lower portions. Leaflets in 45–68 pairs, angled forward 40–50°, opposing leaflets at an angle of about 30–50° to each other, producing a V-shaped cross section, apical leaflets generally paired, glabrous, glaucous blue, flat, spaced 1–5 mm (to 0.2 in) apart, median leaflets 18–21 cm (7.1–8.3 in) long, 4–5 mm (0.2 in) wide, midrib slightly raised above, prominent below, margin slightly revolute. **Female cones** open type. Sporophylls 13–24 cm (5.1–9.4 in) long, glaucous blue, lightly brown tomentose at base, each with two to six ovules, usually four. Lamina broadly triangular, 28–32 mm (1.1–1.3 in) long, 20–25 mm (0.8–1 in) wide, with poorly developed teeth, apical spine 5–15 mm (0.2–0.6 in) long. Sarcotesta yellow-purple with a glaucous bloom when ripe. Sclerotesta 30–39 mm (1.2–1.5 in) long, 32–35 mm (1.3–1.4 in) in diameter. **Male cones** solitary, erect, elongate ovoid, 24–40 cm (9.4–16 in) long, 8–9.5 cm (3.2–3.7 in) in diameter. Peduncle short, cone appearing sessile. Sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face 5 mm (0.2 in) high, 5–15 mm (0.2–0.6 in) wide, projecting 1 cm (0.4 in), apical spine 3–4 mm long. Sporangia in a single patch covering the underside of the sporophyll. **Habitat:** Sparse *Eucalyptus* woodland on shallow soils or rocky outcrops at elevations of about 500 m (1600 ft). Rainfall averages 1000–1500 mm (39–59 in) annually, falling mostly in summer. Temperatures average 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Australia, Queensland, North Kennedy district, to the northwest of Charters Towers.

Cycas desolata was first brought to the attention of the botanical community in late 1993. By early 1995 Paul I. Forster of the Queensland Herbarium, Brisbane, had investigated this newly found stand of *Cycas,* determined that it was an undescribed species, and named it. The closest relative of *C. desolata* is *C. cairnsiana,* also from northern Queensland. *Cycas desolata* differs from *C. cairnsiana* in its linear lanceolate cataphylls, lack of spines at the base of the petiole, fewer leaflets on each leaf, longer and wider median leaflets, microsporophylls with a shorter apical spine, and the smaller and broadly triangular megasporophyll lamina with a longer apical spine.

The blue coloration of the foliage of *Cycas desolata* makes it particularly striking. This feature in itself is enough to make it a much sought after collector's plant. Because of the more recent discovery and description of *C. desolata* there is no information available as to its ease or difficulty in cultivation. One would expect it to be similar to *C. cairnsiana, C. couttsiana,* and *C. platyphylla* in this respect as they come from somewhat similar habitats. *Cycas desolata* is best suited to the dry Tropics but would probably also do reasonably well in climates similar to that of southern California.

Cycas desolata would appear to be not threatened at present. The species is common in its somewhat limited distributional area, and Forster stated that he had observed more than a thousand individuals. The populations occur on private land and are not under threat from the current owner. Of course, the situation could change rapidly, and any change could threaten the species.

Cycas diannanensis Z. T. Guan & G. D. Tao 1995

PLATE 126

Cycas pectinata subsp. *manhaoensis* C. J. Chen & P. Yun 1995

Cycas parvula S. L. Yang ex D. Y. Wang & T. Chen 1996

The epithet for *Cycas diannanensis* refers to Manhao, said to be the type locality in southern Yunnan province, China. **Stems** arborescent, erect or decumbent, 0.8–3 m (2.6–10 ft) long, 30–40 cm (12–16 in) in diameter. **Leaves** erect to slightly spreading, 2.5–3 m (8.1–10 ft) long. Petiole 80–103 cm (32–41 in) long and armed with 36–40 pairs of spines 2–4 mm long, curved slightly backward and downward. Leaflets in 67–138 pairs, linear lanceolate, papery, median leaflets 25–38 cm (10–15 in) long, 14–15 mm (0.6 in) wide, the midrib elevated on both sides. **Female cones** closed type. Sporophylls 26–30 cm (10–12 in) long, each with two to seven ovules that are sometimes slightly tomentose. Lamina round to ovate, glabrous above, tomentose below, margin with 13–20 pairs of narrow, drawn-out lobes 2–3.5 cm (0.8–1.4 in) long. Sarcotesta red-brown when ripe. Sclerotesta flattened globose, 30–36 mm (1.2–1.4 in) long, 21–28 mm (0.8–1.1 in) in diameter. **Male cones** solitary, cylindrical ovoid, densely brown-orange tomentose. Peduncle short, cone appearing sessile. Sporophylls about 4 cm (1.6 in) long. **Habitat:** Scattered individuals in broad-leaved forest or grassland on soils derived from limestone at elevations of 700–1200 m (2300–3900 ft). **Distribution:** China, Yunnan province, reported from Manhao, Gejiu City.

Following its original description in 1995, *Cycas diannanensis* was described in the book *Cycads in China,* published in 1996. In common with the other more recently described species, the English translation was somewhat too concise. The sketchy information used for the description of this species was far from complete. The separation of *C. diannanensis* from *C. balansae* was said to be based on shorter spines on the petiole and the lighter green coloration of the underside of the leaves. It was also said to be similar to *C. simplicipinna,* distinguished from it by the ovate lamina of the megasporophyll with its 13–20 pairs of lateral segments and its sometimes pubescent ovules. We trust that it is a valid species and not a synonym of *C. balansae* or *C. simplicipinna.*

Scant information is available on the cultivation of *Cycas diannanensis.* In China it is in cultivation at the Shenzhen Fairy Lake Botanical Garden, Guangdong province, and the Forestry Institute of Pingbian county and the Xishuangbanna Tropical Botanical Garden, Yunnan province. From this we may gather that *C. diannanensis* is a tropical plant and would do best in tropical to subtropical areas. I have a medium-sized plant that I have been growing outdoors for 2 years. The plant has experienced several periods of frost without damage.

The conservation status of *Cycas diannanensis* was not addressed in its description. As most of the better known species of *Cycas* in China are considered endangered, we must consider *C. diannanensis* to be similarly endangered until additional information becomes available.

Cycas dolichophylla K. D. Hill, H. T. Nguyen & L. K. Phan in Hill et al. 2002

PLATE 127

The epithet for *Cycas dolichophylla* is derived from *dolichos*, Greek for long, and *phyllon*, leaf, referring to the long leaves. **Stems** arborescent, erect, to 1.5 m (4.9 ft) long, 18–30 cm (7–12 in) in diameter. Cataphylls narrowly triangular, soft, articulated, lightly hairy, 8–12 cm (3.2–4.7 in) long. **Leaves** usually 8–40, very glossy, bright green to deep green, 2–4.5 m (6.6–15 ft) long, flat, emergent leaves orange tomentose, soon becoming glabrous. Petiole glabrous, 0.4–1.1 m (1.3–3.6 ft) long, spiny 90–100% of its length. Leaflets in 75–135 pairs, much lighter below than above, flat, apex softly acuminate and not spiny, median leaflets 19–42 cm (7.5–17 in) long, 14–25 mm (0.6–1 in) wide, spaced 16–30 mm (0.6–1.2 in) apart, narrowed to 3–6 mm (to 0.2 in) at the distinctively rounded base, decurrent for 5–8 mm (0.2–0.3 in), midrib raised above, flat below, margin prominently undulate. **Female cones** closed type. Sporophylls 15–26 cm (6–10 in) long, densely brown tomentose, each with two to four glabrous ovules. Lamina rounded, 6–12 cm (2.4–4.7 in) long, 5–10 cm (2–4 in) wide, deeply pectinate, with 16–26 soft lateral spines 40–50 mm (1.6–2 in) long, 2–3 mm wide, apical spine not distinct. Sarcotesta 2–4 mm thick, yellow, not glaucous, fibrous layer absent. Sclerotesta ovoid to flattened ovoid or oblong, 40–64 mm (1.6–2.5 in) long, 33–36 mm (1.3–1.4 in) in diameter. **Male cones** solitary, narrowly ovoid to spindle shaped, 35–50 cm (14–20 in) long, 8–10 cm (3.2–4 in) in diameter, yellow. Sporophylls 30–36 mm (1.2–1.4 in) long, 9–13 mm (0.4–0.5 in) wide. Sporophyll face 2–4 mm long, apical spine rudimentary or absent, when present sharply upturned and to 3 mm long. **Habitat:** Closed evergreen forests on loamy soils over limestone, shale, or granite, generally in deep shade or more sheltered sites. **Distribution:** China, eastern Yunnan province in the extreme southern part of the country. Vietnam, near the Chinese border in the north, to Ben En National Park in the south.

Although *Cycas dolichophylla* is the most widespread and abundant cycad in northern Vietnam, it was not recognized as a distinct species until the late 1990s. *Cycas dolichophylla* belongs to section *Stangerioides,* comprising a closely related complex of species ranging through northern Vietnam, Laos, northern Thailand, and Yunnan province and Guangxi autonomous region of southern China. Generally, *C. dolichophylla* can be separated from its close relatives by its short, thick stem and longer leaves with numerous short, broad, distinctively undulate leaflets.

Cycas dolichophylla is rare in cultivation outside Vietnam. This cycad is not often used in Vietnam as a garden subject because of its very long leaves. Compact cycads are more in demand in Asia, for both gardens and pots. If space permits, *C. dolichophylla* would make an outstanding addition to any garden because of its long, arching leaves with their short, broad, undulate leaflets. This plant would be best suited for use in tropical to subtropical climates.

The conservation status of *Cycas dolichophylla* appears to be secure. It is an abundant species, covering a large geographical area in northern Vietnam.

Cycas edentata de Laubenfels in de Laubenfels & Adema 1998

Cycas circinalis f. *maritima* J. Schuster 1932

The epithet for *Cycas edentata* is derived from *e-*, Latin prefix meaning without, and *dentata*, toothed, thus without teeth, referring to the smooth margins of the megasporophyll lamina. **Stems** arborescent, erect, to 7 m (23 ft) long, 15–30 cm (6–12 in) in diameter. Cataphylls narrowly triangular, soft, lightly tomentose, persistent. **Leaves** numerous, spreading, 1–2.2 m (3.3–7.2 ft) long, 30–65 cm (12–26 in) wide. Petiole 45–69 cm (18–27 in) long, glabrous, armed about 50% of its length. Leaflets in 60–108 pairs, straight to lightly falcate, green above and lighter below, spaced 12–17 mm (0.5–0.7 in) apart, basal leaflets not gradually reduced to spines, median leaflets 27–37 cm (11–15 in) long, 14–18 mm (0.6–0.7 in) wide, midrib raised above and below, margin lightly revolute. **Female cones** open type. Sporophylls 24–34 cm (9.5–13 in) long, densely brown tomentose, each with two to four glabrous ovules. Lamina lanceolate, 43–60 mm (1.7–2.4 in) long, 20–30 mm (0.8–1.2 in) wide, obscurely toothed, with lateral spines to 1 mm long, apical spine distinct, 14–20 mm (0.6–0.8 in) long. Sarcotesta orange to orange brown. Sclerotesta flattened ovoid, 55–66 mm (2.2–2.6 in) long, 45–50 mm (1.8–2 in) in diameter, spongy endocarp present. **Male cones** erect, spindle shaped, 55–60 cm (22–24 in) long, 11–13 cm (4.3–5.1 in) in diameter, orange. Sporophylls 37–44 mm (1.5–1.7 in) long, 12–23 mm (0.5–0.9 in) wide, apical spine prominent, sharply upturned, 13–23 mm (0.5–0.9 in) long. **Habitat:** Along shorelines in full sun or under open rain forest but almost always in close proximity to the ocean. **Distribution:** Philippines, Sulu Archipelago, known only from Calusa Island.

Specimens destined to be described as *Cycas edentata* were first collected in July 1912. It was not recognized as undescribed and was identified as *C. circinalis*. There was no mention of these specimens until Julius Schuster cited them when he described *C. circinalis* subsp. *riuminiana* var. *curranii* f. *maritima* in 1939, a taxon given the rank of species by David de Laubenfels in 1998.

I have no firsthand knowledge of *Cycas edentata,* as I have never seen a living specimen. In his description, de Laubenfels gave no distinguishing features to identify it. He did state that *C. edentata* resembles *C. thouarsii* but also remarked it was a less robust plant. He also stated, "this species is widely used as a food crop just as its relatives."

It can be expected that *Cycas edentata* would grow well in subtropical to tropical areas. I would not expect it to have any problems in cultivation, as long as it is grown under the proper climatic conditions. There is no information available on the conservation status of *C. edentata.*

Cycas elephantipes A. Lindstrom and K. D. Hill 2002

The epithet for *Cycas elephantipes* is derived from the word elephant, and *pes,* Latin for foot, thus elephant foot, referring to the distinctive and very large swollen base of this cycad. **Stems** arborescent, 1–3 m (3.3–10 ft) long, 15–20 cm (6–8 in) in diameter. **Leaves** usually 40–70, semiglossy gray-green, 1–1.6 m (3.3–5.2 ft) long, flat, emergent leaves densely white tomentose. Petiole glabrous, 20–45 cm (8–18 in) long, spiny 10–40% of its length. Rachis consistently terminated by a spine 6–22 mm (0.2–0.9 in) long. Leaflets in 37–150 pairs, median leaflets much lighter below than above, 15–25 cm (6–10 in) long, 6–10 mm (0.2–0.4 in) wide, narrowed to 2.5–4.5 mm (to 0.2 in) at the base, slightly keeled in section, angled forward 45–50°, decurrent for 2–4 mm (to 0.2 in), midrib flat above, raised below, margin slightly revolute, apex acute, spiny. **Female cones** closed type. Sporophylls densely gray tomentose, to 20 cm (8 in) long, each with two to four glabrous ovules. Lamina round to ovate, about 12 cm (4.8 in) long and 8 cm (3.1 in) wide, deeply pectinate, with about 18 soft lateral spines 45 mm (1.8 in) long, 3 mm wide, apical spine distinct, 55 mm (2.2 in) long, 4 mm wide at the base. Sarcotesta yellow. Sclerotesta flattened ovoid, smooth. **Male cones** solitary, ovoid or narrowly ovoid, 30–55 cm (12–22 in) long, 12–16 cm (4.7–6.3 in) in diameter, orange or brown tomentose. Sporophylls 4–4.5 cm (1.6–1.8 in) long. Sporophyll face 5–7 mm (0.2–0.3 in) high, 18–22 mm (0.7–0.9 in) wide, apical spine prominent, sharply upturned or gradually raised, 15–30 mm (0.6–1.2 in) long. **Habitat:** Seasonally dry, deciduous, open to closed woodland with a predominantly grassy understory, the cycad found only near the summit of a few broad, high, sandstone massifs or mesas. **Distribution:** Thailand, northern central part of the country, Chaiyaphum, Nong Bua Raheo.

Cycas elephantipes is one of the more recently discovered species from Thailand. It closely resembles *C. pachypoda* from southern Vietnam because of its rough stem of dark, deeply fissured, corky bark and its flat, erect, dull to semiglossy gray-green leaves with narrow, keeled leaflets that are angled forward. It differs in its overall larger size, larger leaves and leaflets, and larger male cones with longer microsporophylls and longer apical spines.

Cultivation of *Cycas elephantipes* will no doubt have to be limited to tropical climates or greenhouse culture. This species, because of its decorative properties, has become a popular landscape plant in cities near its habitat.

The conservation status of *Cycas elephantipes* is rapidly declining through uncontrolled harvest of the plants for sale in local communities. If this practice continues, *C. elephantipes* could become critically endangered. This species is not known to occur in any protected areas.

Cycas elongata (Leandri) D. Y. Wang & T. Chen 1996, as *"elonga"*

PLATES 128–130

Cycas pectinata var. *elongata* Leandri 1931, *Epicycas elongata* (Leandri) S. L. Yang in de Laubenfels & Adema 1998

The epithet for *Cycas elongata* is derived from *elongatus,* Latin for elongated, referring to the elongated apical spine of the megasporophyll lamina. **Stems** arborescent, erect, often branched, 0.5–3 m (1.6–10 ft) tall, 12–17 cm (4.7–6.7 in) in diameter, base swollen to twice the stem diameter, crown lacking tomentum, bark in older specimens becoming rough and fissured. Cataphylls narrowly triangular, soft, 8–10.9 cm (3.2–4.3 in) long, 19–21 mm (0.7–0.8 in) wide, lightly gray tomentose or glabrous. **Leaves** usually 50–80, erect, semiglossy, deep green to gray-green, 0.9–1.3 m (3–4.3 ft) long, 21–30 cm (8.3–12 in) wide, slightly keeled. Petiole 10–20 cm (4–8 in) long, spiny 80–100% of its length with 15–36 pairs of downward-angled spines 3–4 mm long and spaced 10–25 mm (0.4–1 in) apart. Rachis usually terminated by a spine 5–15 mm (0.2–0.6 in) long. Leaflets in 68–133 pairs, gray-green, linear lanceolate, much lighter below than above, median leaflets 12–18 cm (4.7–7.1 in) long, 5–8 mm (0.2–0.3 in) wide, midrib flat to slightly raised above, raised below, margin flat to slightly revolute. **Female cones** closed type. Sporophylls 7–15 cm (2.8–5.9 in) long, brown tomentose, each with two to four glabrous ovules. Lamina rounded, 9–12 cm (3.5–4.7 in) long, 4–7 cm (1.6–2.8 in) wide, deeply pectinate, with 30–36 soft lateral spines 1–2 cm (0.4–0.8 in) long, 1–2 mm wide, apical spine distinct, 1.5–4 cm (0.6–1.6 in) long, 4–5 mm (0.2 in) wide at its base. Sarcotesta yellow when ripe, fibrous layer absent. Sclerotesta flattened ovoid, smooth. **Male cones** solitary, erect, narrowly ovoid, 25–40 cm (10–16 in) long, 10–15 cm (4–6 in) in diameter, orange to brown. Sporophylls 40–52 mm (1.6–2 in) long. Sporophyll face 15–20 mm (0.6–0.8 in) wide, projecting 7–12 mm (0.3–0.5 in), apical spine sharply upturned, 9–15 mm (0.4–0.6 in) long. Sporangia in a single patch. **Habitat:** Arid coastal rocky hills with sandy soils, generally at low elevations. The original vegetation was low open monsoon savanna woodland, but most of the woodland has been cut for fuel. **Distribution:** Vietnam, Bình Thuân province, at Thôn Lac Nghiêp (Ca Na), southwest of Phan Rang.

In 1931, Jacques Désiré Leandri described *Cycas pectinata* var. *elongata* from Vietnam. It was said to be closely related to *C. pectinata,* differing from that species by its longer apical spines of the megasporophyll lamina. Because of political problems, no botanical research by foreigners was possible until the 1990s. In late 1994, S. L. Yang, a Chinese botanist researching Asian *Cycas* for the Montgomery Botanical Center, Miami, Florida, studied this species near Thôn Lac Nghiêp (Ca Na), Vietnam. He felt that it was sufficiently distinct and in his report suggested that variety *elongata* be elevated to the rank of species. Later, D. Y. Wang of the Shenzhen Fairy Lake Botanical Garden, China, investigated these same plants. In 1996 the book *Cycads in China* was published, in time for Cycad 96, the Fourth International Conference on Cycad Biology, held in Panzhihua, Sichuan, and in it variety *elongata* was raised to the level of species. I have not been able to study *C. elongata,* either in cultivation or in its habitat, therefore I cannot remark on its differences with *C. pectinata.* I respect the opinions of Kenneth D. Hill and S. L. Yang because of their extensive fieldwork on *Cycas* in China, Vietnam, and Thailand, and they both agree that *C. elongata* is a distinct species.

There are no data of which I am aware relating to the cultivation of *Cycas elongata.* On the other hand, there is no reason to believe that *C. elongata* should present any problems. It would definitely do best in a tropical climate. Its large size would require sufficient space for proper development. Other than that, I would expect no problems.

The conservation status of *Cycas elongata* is difficult to ascertain as there has not been a great deal of information made available as to its range or numbers in habitat. Yang and Hill agree that *C. elongata* is common in some areas, in coastal woodland on rocky land. The habitat of *C. elongata* borders the beach. Therefore, land development could cause conservation problems. The conservation information available has caused this species to be considered not threatened.

Cycas falcata K. D. Hill 1999a

The epithet for *Cycas falcata* is derived from *falcatus*, Latin for falcate or curved in a sickle shape, referring to the distinctively curved leaflets. **Stems** erect, unbranched or occasionally branched at the base, to 5 m (16 ft) tall, 12–30 cm (4.7–12 in) in diameter. Cataphylls broadly triangular, soft, densely brown tomentose, 4–7 cm (1.6–2.8 in) long. **Leaves** numerous, glossy olive green, 1.8–3 m (5.9–10 ft) long, mildly keeled, emergent leaves tomentose, soon becoming glabrous. Petiole glabrous, 27–62 cm (11–24 in) long, armed with spines 80–100% of its length. Leaflets in 50–100 pairs, median leaflets often strongly falcate, keeled, 17–30 cm (6.7–12 in) long, 7.5–13 mm (0.3–0.5 in) wide, narrowed to 3–4 mm at the base, decurrent for 5–7 mm (0.2–0.3 in), spaced 11–17 mm (0.4–0.7 in) apart, midrib green, strongly raised above, slightly raised below, margin curved slightly backward and downward. **Female cones** open type. Sporophylls 19–27 cm (7.5–11 in) long, densely medium brown tomentose, each with 4–6 glabrous ovules. Lamina narrowly triangular, 60–70 mm (2.4–2.8 in) long, 22–32 mm (0.9–1.3 in) wide, shortly pectinate, with 16–28 more or less pungent lateral spines 7–12 mm (0.3–0.5 in) long, apical spine distinct, 15–28 mm (0.6–1.1 in) long, 2.5–4 mm wide. Sarcotesta orange yellow, not glaucous, fibrous layer absent. Sclerotesta flattened ovoid, not crested apically or only weakly so, 42–46 mm (1.7–1.8 in) long, 30–34 mm (1.2–1.4 in) wide, 25–30 mm (1–1.2 in) in diameter, interior spongy layer present. **Male cones** not described. **Habitat:** Closed forest to open short-tree savanna with grasses dominant, in full sun to heavy shade, generally on limestone or serpentine substrates. **Distribution:** Indonesia, islands of Sulawesi, and Kabaena.

Cycas falcata is a relatively unknown species that is probably not grown outside its native habitat, except possibly in other areas of Indonesia. *Cycas falcata* has been placed within the *C. rumphii* complex because of the presence of the spongy endocarp within the sclerotesta of its seed. It departs from the *C. rumphii* complex because of the deeply toothed or shortly pectinate margins on the megasporophyll lamina and its preference for inland habitats as opposed to the coastal sites preferred by all other cycads in the complex.

Cultivation of *Cycas falcata* should not be different from other subtropical to tropical species of the genus. Judging from the description of its leaves *C. falcata* must be a handsome cycad and should make a fine ornamental once it is introduced into cultivation.

Cycas falcata is not considered as threatened. Its limited distribution, however, could make it vulnerable. Further field study is required to evaluate its status properly.

Cycas ferruginea F. N. Wei 1994

The epithet for *Cycas ferruginea* is derived from *ferrugineus*, Latin for rusty red, referring to the abundant deep red tomentum in the crown. **Stems** subterranean to arborescent, to 1.2 m (3.9 ft) long, 12–18 cm (4.7–7 in) in diameter. Cataphylls narrowly triangular, pungent, lightly tomentose, 9–12 cm (3.6–4.7 in) long, persistent. **Leaves** generally 10–25, semiglossy to very glossy, deep green to gray green, 1.3–2.1 m (4.3–6.9 ft) long, slightly keeled or flat, emergent leaves densely covered with white, orange, or brown tomentum, shedding as leaves emerge but often persistent on the lower surfaces. Petiole 35–80 cm (14–32 in) long (25–40% of total leaf length), glabrous or lightly tomentose, spiny 30–100% of its length. Rachis generally terminated by paired leaflets. Leaflets in 60–100 pairs, much lighter below than above, often falcate, often with tomentum persisting on the lower surface, basal leaflets not gradually reduced to spines, 8–19 cm (3.2–7.5 in) long, median leaflets 19–38 cm (7.5–15 in) long, 8–13 mm (0.3–0.5 in) wide, narrowed to 2.5–4 mm at the base, decurrent for 4–8 mm (to 0.3 in), spaced 10–19 mm (0.4–0.8 in) apart, slightly keeled, apex acute and spiny, midrib raised above, flat below, margin curved backward and downward. **Female cones** closed type. Sporophylls 11–19 cm (4.3–7.5 in) long, densely brown tomentose, each with two to six glabrous ovules. Lamina rounded, 7–11 cm (2.8–4.3 in) long, 5–8 cm (2–3.2 in) wide, deeply pectinate, with 28–42 soft lateral spines 18–40 mm (0.7–1.6 in) long, 1–3 mm wide, apical spine distinct, 15–50 mm (0.6–2 in) long, 3–8 mm (to 0.3 in) wide at its base. Sarcotesta 1–2 mm thick, yellow, not glaucous, fibrous layer absent. Sclerotesta ovoid, rough and warty, 19–24 mm (0.8–0.9 in) long, 15–21 mm (0.6–0.8 in) in diameter. **Male cones** solitary, spindle shaped, 25–45 cm (10–18 in) long, 4–6 cm (1.6–2.4 in) in diameter, orange. Sporophyll 16–20 mm (0.6–0.8 in) long, 9–13 mm (0.4–0.5 in) wide. Sporophyll face projecting 3–5 mm (to 0.2 in), apical spine rudimentary or absent, when present sharply upturned, to 3 mm long. **Habitat:** Bare limestone cliffs or bluffs. **Distribution:** Vietnam, northern part of the country, Làng Son province, restricted to a belt of limestone bluffs.

Cycas ferruginea was described by F. N. Wei in 1994, based on a cultivated plant at the Guilin Botanic Garden, Guangxi autonomous region, China. The original collection locality was not known at the time, and subsequent efforts to locate wild plants in southern China met with failure. In 1997, field studies of *Cycas* in northern Vietnam disclosed the presence of a large colony of cycads that appear to match the type plant of *C. ferruginea* in Guilin. This would seem to indicate that *C. ferruginea* is a Vietnamese endemic.

Cycas ferruginea appears to be most closely related to *C. revoluta* but can be separated from that species by the densely red-brown tomentose stem apex and new growth. *Cycas ferruginea* also differs from *C. revoluta* in its overall larger measurements, with longer leaves with longer, often falcate leaflets with margins curved backward and downward, and a larger, broader megasporophyll lamina with a distinct, broad apical spine.

Here again we have a very handsome cycad that is virtually unknown outside Vietnam. If *Cycas ferruginea* ever becomes commonly available, I am sure it will be a popular landscape plant. Like other Vietnamese *Cycas* species, *C. ferruginea* would be best suited to a tropical or subtropical climate, but the inherent cold tolerance of the genus might make it usable in warm temperate to temperate climates as well. Its habitat preference for limestone cliffs would indicate a well-drained potting mix or planting area for best results.

The conservation status of *Cycas ferruginea* appears to be very good. There are still large populations in remote areas not often visited by plant collectors.

Cycas fugax K. D. Hill 2000

PLATE 131

The epithet for *Cycas fugax* is Latin for fleeting, referring to the near extinction of this cycad before it was botanically recognized. **Stems** subterranean, 8–12 cm (3.2–4.7 in) in diameter. Cataphylls linear, soft, lightly tomentose, 5–6 cm (2–2.4 in) long, persistent. **Leaves** generally one to three, very glossy or semiglossy, deep green, 2.8–4 m (9.2–13 ft) long, flat, emergent leaves densely orange tomentose, soon becoming glabrous. Petiole 1.5–2.2 m (4.9–7.2 ft) long (50–60% of total leaf length), glabrous, spiny 90–95% of its length. Rachis terminated by paired leaflets. Leaflets in 35–55 pairs, much lighter below than above, flat, basal leaflets not gradually reduced to spines, 30–40 cm (12–16 in) long, median leaflets 42–50 cm (17–20 in) long, 19–31 mm (0.8–1.2 in) wide, angled forward 65–70°, narrowed to 2–2.5 mm at the base, decurrent for 2–6 mm (to 0.2 in), spaced 3–4 cm (1.2–1.6 in) apart, midrib raised above and below, margin flat or undulate. Female cones closed type. Sporophylls 20–24 cm (8–9.5 in) long, densely brown tomentose, each with two to four glabrous ovules. Lamina ovate, 11–13 cm (4.3–5.1 in) long, 3.5–4 cm (1.4–1.6 in) wide, deeply pectinate, with 10–12 soft lateral spines 8–10 cm (3.2–4 in) long, 3 mm wide, apical spine not distinct. Sarcotesta yellow, not glaucous, fibrous layer absent. Sclerotesta subglobose, rough and warty, 18–22 mm (0.7–0.9 in) long and in diameter, spongy endocarp absent. Male cones solitary, spindle shaped, 10–12 cm (4–4.7 in) long, 2.5–5 cm (1–2 in) in diameter, yellow. Sporophyll face with the apical spine either prominent or rudimentary, when present sharply upturned, 2–5 mm (to 0.2 in) long. Habitat: Originally in closed evergreen forests at an elevation of about 200 m (650 ft), according to collectors, but no remaining habitat known to exist. Distribution: Historically, Vietnam, northern part of the country, Phú Tho province.

Cycas fugax is the only species of the genus of which I am aware that may no longer exist in the wild. The entire known former habitat has been cleared for agriculture or urbanization. *Cycas fugax* can now only be found in cultivation. The distinguishing characteristics of *C. fugax* are the few, long leaves with widely spaced leaflets, small male cones with microsporophylls that possess a distinct apical spine, and elongated teeth on the megasporophylls that lack a clearly distinct apical spine.

Cycas fugax is said to be reasonably common in cultivation in Hanoi, Vietnam. Because of its very few, extremely long leaves, *C. fugax* does not sound like a particularly handsome cycad. In spite of this, plant collectors from Hanoi, in conjunction with habitat loss, have apparently eradicated *C. fugax* from the areas where it used to grow naturally outside the city. In cultivation, *C. fugax* would require a tropical to subtropical climate, moist rich soil, and overhead cover.

Cycas fugax can be considered as critically endangered; the species is in need of propagation and conservation.

Cycas furfuracea W. V. Fitzgerald 1918

PLATES 132, 133

Cycas media var. *furfuracea* (W. V. Fitzgerald) J. Schuster 1932

The epithet for *Cycas furfuracea* is derived from *furfuraceus,* Latin and meaning covered with branlike scales or powder, referring to the persistent tomentum on all parts of this cycad. Stems arborescent, erect, single or rarely branched due to injury, seldom suckering at the base, 2–4 m (6.6–13 ft) tall, 17.5–25 cm (7–10 in) in diameter, average plants with trunks 1.3 m (4.3 ft) tall, 20 cm (8 in) in diameter. Cataphylls narrowly triangular, soft. Leaves as many as 70 in a crown, straight, 1.1–1.3 m (3.6–4.3 ft) long, 32–35 cm (13–14 in) wide, strongly keeled, slightly curved inward at the tip, strongly blue-gray, the color persistent, emergent leaves with persistent rust brown tomentum. Petiole 15–26 cm (6–10 in) long, usually armed but may be only partially armed or completely unarmed. Leaflets in 50–110 pairs, stiff, abruptly shortened toward the base and gradually toward the apex, angled forward 40–70°, spaced 9–13 mm (0.4–0.5 in) apart, basal leaflets gradually reduced to spines, median leaflets 7–20 cm (2.8–8 in) long, 6–8 mm (0.2–0.3 in) wide, midrib prominent above and below, margin flat, entire, curved slightly backward and downward. Female cones open type. Sporophylls 26–36 cm (10–14 in) long, each with four to eight ovules. Lamina 7–9.5 cm (2.8–3.7 in) long, 1–2.5 cm (0.4–1 in) wide, regularly toothed, with 12–20 lateral spines 2–5 mm (to 0.2 in) long, 2–3 mm wide, apical spine 25–65 mm (1–2.6 in) long. Sarcotesta light blue-gray that persists to maturity, under the waxy gray covering the ripe seed orange-brown. Sclerotesta 32–36 mm (1.3–1.4 in) long, 27–32 mm (1.1–1.3 in) in diameter, light tan, the surface more or less smooth. Male cones solitary, erect, narrowly ovoid to spindle shaped, 30–40 cm (12–16 in) long, 7–9 cm (2.8–3.5 in) in diameter, orange to brown tomentose. Sporophylls 3–4 cm (1.2–1.6 in) long. Sporophyll face 16–20 mm (0.6–0.8 in) wide, terminal spine upright, 6–12 mm (0.2–0.5 in) long. Sporangia in a single patch. Habitat: Often on steep west-facing slopes of sandy soil and sandstone or quartzite boulders, under partial cover of *Eucalyptus* at elevations of 250–300 m (820–980 ft). The habitat is very dry with rainfall averaging 1500 mm (59 in) annually, falling mainly in summer. Summer temperatures average 36°C (97°F) during the day, 29°C (84°F) at night; winter temperatures average 14–26°C (57–79°F). Distribution: Australia, northeastern Western Australia, restricted to relatively remote areas in the vicinity of Bold Bluff, Mount Broome, and Mount Herbert in the King Leopold Range, also reported from the Kimbolton area.

Cycas furfuracea was described in 1918 by William Vincent Fitzgerald after an expedition to the Kimberley

Range in northern Western Australia. It was noted again by Charles A. Gardner (1923) when he wrote about the Kimberley Exploration Expedition of 1921. In 1932 Julius Schuster reduced the species to a variety of *C. media,* but his opinion was not widely accepted. The taxonomy of *Cycas* in Western Australia is now stable and no further changes are anticipated.

I have found no mention in the literature of *Cycas furfuracea* being utilized as a food item by the Aborigines. This is strange since the country is very dry and old Aboriginal camps are not uncommon. In almost every instance these camps are located in or near groves of *Pandanus,* which were, and still are, used as a source of food.

It is strange that a beautiful and decorative cycad such as *Cycas furfuracea* is so rare in private collections and botanical gardens. The remote habitat no doubt played a major role in the scarcity of this species in collections for so many years. In more recent times, some seed and plant collections have been made, and the cycad appears to do quite well in cultivation. Seedlings and younger specimens sometimes have problems with damping-off if given too much water. Potting in a well-drained mix and being careful not to overwater, especially during winter, seem to be all that is necessary to make the plants grow well. Whatever problems are involved with its cultivation, the beauty of *C. furfuracea* makes it a worthwhile effort. *Cycas furfuracea* is one of the most robust of the gray-leaved species of Australian *Cycas.* The thick trunks and large numbers of straight, heavily keeled, blue-gray leaves make it a striking cycad both in its habitat and in cultivation.

The conservation status of *Cycas furfuracea* appears to be very good. The individual populations are large, and seed production and regeneration copious. There do not appear to be any major predators, either insects or larger animals, for this species. The major protection afforded this cycad is its remote and rugged habitat, which makes access very difficult without a good four-wheel-drive vehicle and strong legs. It appears that the habitat has not changed or been visited often since its discovery.

Cycas guizhouensis K. Lan & R. F. Zhou 1983

PLATE 134

Cycas multiovula D. Y. Wang in Wang & Chen 1996
Cycas longlinensis H. T. Chang & Y. C. Zhong 1997

Cycas guizhouensis, the epithet referring to Guizhou province, China, where this cycad is native, is called Guizhou *su-tie, feng-wei-cao, guan-yin-lian,* and *shan-bo-luo.* STEMS arborescent, usually solitary, erect, 0.6–2 m (2–6.6 ft) tall, mature plants often forming clumps by suckering from the base. Cataphylls long deltoid, 2–5 cm (0.8–2 in) long, 1.2–2 cm (0.5–0.8 in) wide at the base. LEAVES numerous, erect, dark green above, paler green below, 0.6–1.6 m (2–5.2 ft) long, slightly arching. Petiole 30–50 cm (12–20 in) long, armed with 29–73 pairs of straight spines 2–4 mm long and spaced 5–25 mm (0.2–1 in) apart. Leaflets in 47–82 pairs, linear lanceolate, slightly falcate, glabrous, closely spaced, leathery, apex gradually acuminate, base decurrent, median leaflets 8–18 cm (3.2–7.1 in), rarely as long as 23 cm (9 in) long, 8–12 mm (0.3–0.5 in) wide, midrib prominent above and below, margin flat or lightly revolute. FEMALE CONES closed type. Sporophylls 14–20 cm (5.5–8 in) long, dark yellow-brown or rusty brown tomentose, each with two to six glabrous ovules, rarely as many as nine. Lamina rounded to ovate or elliptical, 4.5–10 cm (1.8–3.9 in) long, 5–8 cm (2–3.2 in) wide, margin regularly pectinate, with 17–23 pairs of spinelike segments 2–5 mm (to 0.2 in) long, 1–4 mm wide, apical spine 3–5 cm (1.2–2 in) long, 11–17 mm (0.4–0.7 in) wide, with three to five lobes at its apex, the segments with an acute apex that is usually glabrous, their margins and base densely yellow-brown tomentose. Sarcotesta yellow when ripe. Sclerotesta ovoid to globose, 19–25 mm (0.8–1 in) long, 18–22 mm (0.7–0.9 in) in diameter, smooth. Chalaza consisting of two pits 4–5 mm (0.2 in) wide. MALE CONES solitary, erect, spindle shaped, cylindrical, or ellipsoid cylindrical, 20–53 cm (8–21 in) long, 5–11 cm (2–4.3 in) in diameter, yellow tomentose, cones produced April to July. Peduncle 3–4 cm (1.2–1.6 in) long, about 2.5 cm (1 in) in diameter. Sporophylls wedge shaped, 1.5–4 cm (0.6–1.6 in) long. Sporophyll face triangular, 9–17 mm (0.4–0.7 in) wide, projecting 3–5 mm (to 0.2 in), densely tomentose, apical spine erect, 1–3 mm long. Sporangia in a single patch. HABITAT: Steep river valleys at elevations of 400–800 m (1300–2600 ft), generally in soil composed of limestone gravel and humus. Rainfall averages 1000 mm (40 in) annually, falling mainly in summer. The average yearly temperature is 18.5°C (65°F) with summer highs about 38.5°C (101°F) and winter lows about –2.5°C (27.5°F). Summers are hot and wet and winters dry with occasional frosts. DISTRIBUTION: China, Guizhou province, Xingui district, mainly in the valleys of the Nanpan and Quinshui Rivers, also reported from Guangxi autonomous region, near Xilin and Leye.

Cycas guizhouensis is a relatively recently described species first reported as in cultivation on the grounds of Xingyi Hospital, Guizhou province, China. These plants were thought to have been originally collected at Wantun, Xingyi district. K. Lan and R. F. Zhou consider *C. pectinata* to be its closest relative.

Cycas guizhouensis is said to "grow quickly and well even in poor soils." It was also stated, "although not frost resistant, it is resistant to cold temperatures." From all reports, *C. guizhouensis* is grown extensively as an ornamental in towns located near its habitat. To my knowledge there are no problems associated with its cultivation.

In 1995, *Cycas guizhouensis* was reported to be one of the most endangered cycad species in China, and it was thought possible for it to become extinct in habitat within 5 years. Although this species at one time had a wide range, habitat destruction has been extensive, thereby limiting its chances of survival. During China's Cultural Revolution the cycad was eaten as a famine food by the local minorities. As a result of food shortages, *C. guizhouensis* was almost eaten to extinction. *Cycas guizhouensis* must be considered critically endangered.

Cycas hainanensis C. J. Chen ex C. Y. Cheng, W. C. Cheng & L. K. Fu 1975

PLATE 135

The epithet for *Cycas hainanensis* refers to the island and province of Hainan, China, where this cycad is endemic. **Stems** arborescent, erect, 0.4–3.5 m (1.3–12 ft) tall, 16–48 cm (6.3–19 in) in diameter, with age the lower stem becoming smooth or slightly fissured. Cataphylls about 6 cm (2.4 in) long and 2 cm (0.8 in) wide. **Leaves** usually 13–32, glossy dark green, upright, then spreading, 2.4–3.1 m (7.9–10 ft) long, 52.5–59 cm (21–23 in) wide, flat. Petiole 0.9–1.1 m (3–3.6 ft) long, 1 cm (0.4 in) in diameter just above the expanded base, armed from lowest leaflets to the base with 37–45 pairs of downward-angled spines 8 mm (0.3 in) long and spaced about 25 mm (1 in) apart. Leaflets in 69–144 pairs, linear lanceolate, gradually acuminate, angled forward acutely, spaced 2–3 cm (0.8–1.2 in) apart, median leaflets 30–33 cm (12–13 in) long, 12–14 mm (0.5–0.6 in) wide, the longest leaflets at the leaf base, becoming gradually shorter toward the apex, the lowest two or three pairs of leaflets twisted so as to present the upper surface toward the leaf apex, and bent inward so that the leaflets are almost parallel to each other and touching, midrib prominent above and below, margins flat and straight, rarely undulate, the attachment constricted on both sides almost to the midrib but the lower margin narrowly decurrent to the next leaflet below. **Female cones** closed type, about 22 cm (8.7 in) high and 38 cm (15 in) wide. Sporophylls 16–24 cm (6.3–10 in) long, densely brown tomentose, the stalk 10–15 cm (4–6 in) long and usually bearing four to six glabrous ovules. Lamina rhomboid to ovate, about 7 cm (2.8 in) long and 5 cm (2 in) wide, with five to seven pairs of segments, the terminal segment conspicuously widened, 3.5–4 cm (1.4–1.6 in) long, 1.5–2 cm (0.6–0.8 in) wide. Sarcotesta 2–3 mm thick, yellow-orange when ripe. Sclerotesta subglobose with a small projecting point at the chalaza, 28–35 mm (1.1–1.4 in) long, 25–30 mm (1–1.2 in) in diameter, tan, the surface irregularly fissured. **Male cones** solitary, cylindrical to narrow ellipsoid, 49–70 cm (19–28 in) long, 9–13 cm (3.5–5.1 in) in diameter, yellowish green, lightly light brown tomentose. Sporophyll face with a short upright spine. **Habitat:** Solitary or widely scattered, growing in semishade. Hot, wet, lowland tropical jungle but reported from elevations of 50–1700 m (160–5600 ft). Rainfall averages 2000 mm (79 in) annually, falling throughout the year. Temperatures range from 24°C (75°) in January to 28°C (82°F) in July. **Distribution:** China, Guangdong province and the island and province of Hainan, Wanning and Haikou districts.

Cycas hainanensis is quite distinct from the other Chinese species of the genus, both in its leaves and female cone. In the book *Cycads in China* (1996), D. Y. Wang stated that *C. hainanensis* might be placed into synonymy under *C. taiwaniana* of Mainland China because the megasporophylls of *C. hainanensis* fall within the range of variability of those of *C. taiwaniana.* The remote habitat of *C. hainanensis* would be a strong indication of specific distinction between the two. The need for additional investigation is apparent.

The habitat of *Cycas hainanensis* is hot, wet, tropical forest, where it occurs as scattered individuals. The available information indicates that *C. hainanensis* has not been observed in dense colonies as many of the other species of *Cycas* often occur.

In cultivation, *Cycas hainanensis* adapts quite well to various situations and soils, and under greenhouse or subtropical garden conditions grows relatively rapidly from seed. It has been written that "it cannot tolerate frost or direct sunlight," but this has not been my experience. I have wintered 2-year-old seedlings under 48% shade cloth where the temperature reached −1 to −2°C (29–30°F), which produced only marginal leaf burn. *Cycas hainanensis* is one of the more distinctive species of the genus and would no doubt become popular if sufficient propagation material became available. It is hoped that seed will be obtained from China so that this cycad may become better established in cultivation.

The conservation status of *Cycas hainanensis* is not good. Tang (1998) reported it as under pressure from road and tourist resort construction, with resultant degradation of its habitat. It is hoped that a forest area containing a population of *C. hainanensis* will be set aside for its protection. In the meantime, every effort should be made to establish breeding colonies of *C. hainanensis* in countries with climates compatible to its needs. *Cycas hainanensis* must be considered threatened.

Cycas hoabinhensis K. D. Hill, H. T Nguyen & L. K. Phan in Hill et al. 2002

PLATE 136

The epithet for *Cycas hoabinhensis* refers to Hòa Bình province, northern Vietnam, where this cycad occurs. **Stems** subterranean to arborescent, to 60 cm (24 in) long, 5–8 cm (2–3.2 in) in diameter. Cataphylls narrowly triangular, soft, articulated, lightly tomentose, 5–7 cm (2–2.8 in) long. **Leaves** generally 2–10, very glossy bright green, 0.5–1.3 m (1.6–4.3 ft) long, flat, emergent leaves densely white tomentose but soon glabrous. Petiole 25–60 cm (10–24 in) long (40–60% of total leaf length), glabrous, spiny 100% of its length. Rachis terminated with paired leaflets. Leaflets in 20–50 pairs, much lighter below than above, flat, apex softly acuminate, not spiny, basal leaflets not gradually reduced to spines, 15–25 cm (6–10 in) long, median leaflets 20–28 cm (8–11 in) long, 11–21 mm (0.4–0.8 in) wide, narrowed to 2.5–5 mm (to 0.2 in) at the base, decurrent for 2–4 mm, spaced 15–20 mm (0.6–0.8 in) apart, midrib raised above and below, margin flat or undulate. **Female cones** closed type. Sporophylls about 7 cm (2.8 in) long, densely brown tomentose, each with two to four glabrous ovules. Lamina rounded, about 3 cm (1.2 in) long and 2 cm (0.8 in) wide, deeply pectinate, with 10 soft lateral spines about 20 mm (0.8 in) long and 2.5 mm wide, apical spine not distinct. Sarcotesta yellow, not glaucous, fibrous layer absent. Sclerotesta rough and warty, spongy endocarp absent. **Male cones** solitary, narrowly ovoid or spindle shaped, 10–12 cm (4–4.7 in) long, 5–6 cm (2–2.4 in) in diameter, yellow. Sporophylls about 22 mm (0.9 in) long and 10 mm (0.4 in) wide. Sporophyll face about 2 mm long, apical spine prominent or rudimentary, when present sharply upturned, 4–10 mm (to 0.4 in) long. **Habitat:** Ridge crests on steep limestone outcrops and cliffs under a canopy of closed evergreen forest. **Distribution:** Vietnam, northern part of the country, Hòa Bình province, just south of Hanoi.

Cycas hoabinhensis is a more recently described dwarf species of the genus from northern Vietnam. It is distinguished not only by its small size but also by its small megasporophylls and the slender apical spines on the microsporophylls. The closest relatives of *C. hoabinhensis* are *C. brachycantha* and *C. chevalieri,* both of which have small megasporophylls, but both those species are larger in stature. Very old plants of *C. hoabinhensis* develop a short, very slender, often twisted or decumbent aerial stem.

Cycas hoabinhensis, because of its small size, has been a very popular pot and garden plant in northern Vietnam, especially Hanoi. As far as I am aware, *C. hoabinhensis* has not been introduced into cultivation outside Vietnam. There is no doubt that this cycad would be a popular garden plant in other countries if supplies became available. *Cycas hoabinhensis* will require a tropical to subtropical climate and a well-drained potting mix for best results in cultivation.

Cycas hoabinhensis is considered threatened. Collectors for the ornamental plant trade in Hanoi have drastically reduced many of the more accessible populations of *C. hoabinhensis.* Large populations remain in relatively inaccessible areas, but the extensive depletion gives cause for concern, and this species must be considered at risk.

Cycas hongheensis S. Y. Yang & S. L. Yang ex D. Y. Wang & T. Chen 1996

PLATE 137

The epithet for *Cycas hongheensis* refers to the Red River, called the Hong in Vietnam and the Yuan in China, and also to the southern Yunnan region where this cycad occurs. **Stems** usually branched, 1–2 m (3.3–6.6 ft) long, rarely as long as 7 m (23 ft), 30–40 cm (12–16 in) in diameter, base swollen, the surface smooth, whitish gray with some prominent raised rings, the apex glabrous, and leaf bases persisting only near the apex. Cataphylls stiff, 3–4.5 cm (1.2–1.8 in) long, 1 cm (0.4 in) wide at the base, with pungent apex, the outer surface covered by yellowish brown tomentum, the inner surface smooth. **Leaves** numerous, 50–90 cm (20–35 in) long, rarely as long as 1.2 m (3.9 ft), glaucous green, keeled, emergent leaves yellowish brown tomentose, the tomentum persisting on the lower surface of the leaflets. Petiole 10–20 cm (4–8 in) long, armed with 9–14 pairs of spines in the upper half to two-thirds. Leaflets in 50–70 pairs, leathery, the upper surface with a bluish waxy coating, the lower surface yellowish green, gradually acuminate to a pungent apex, median leaflets 8–16 cm (3.2–6.3 in) long, 6–8 mm (0.2–0.3 in) wide, angled forward 45–75°, midrib not raised above, prominent below, margin straight and lightly revolute. **Cones** not described. **Habitat:** River valleys in full sun on hot, dry, limestone hillsides. **Distribution:** China, Yunnan province, Shiping county, near Nujie village, possibly also in Vietnam (?).

Cycas hongheensis was described in the book *Cycads in China* (1996), which lacked data on both female and male cones. *Cycas hongheensis* somewhat resembles *C. pectinata* and *C. revoluta* though electrophoretic analysis of these three taxa shows no close relationship. The trunk of *C. hongheensis* is similar to that of *C. pectinata,* but *C. hongheensis* differs in that its leaves are shorter and have a distinctive bluish waxy coating, and its cataphylls are stiff and sharp. The keeled leaves and compact crown of *C. hongheensis* somewhat resemble those of *C. revoluta,* but *C. hongheensis* differs in the bluish waxy coating of the leaves, less revolute leaflet margins, and lack of tomentum at the trunk apex.

Cultivation of *Cycas hongheensis* seems to pose no difficulties, at least in China, and it is a popular garden and landscape plant. As would be expected, the waxy bluish foliage makes it very tolerant of open, sunny conditions. It should also be expected to be drought resistant. Both its size and color make it an ideal garden subject. *Cycas hongheensis* is almost unknown in cultivation outside China.

The description of *Cycas hongheensis* came too late to save it in its habitat. As with many other decorative plants, the beauty of this species has led to its near extinction. *Cycas hongheensis* looks somewhat like a gray *C. revoluta* in general appearance. The Chinese people feel that *C. revoluta,* with its compact head of leaves, is a very desirable pot and garden plant. For this reason, *C. hongheensis* has almost been eradicated from its habitat by commercial collecting. The only plants remaining are those that were too large to remove, and even those have had their crowns cut off and offsets removed. *Cycas hongheensis* must be considered extremely endangered; the species is on the brink of extinction in the wild.

Cycas inermis de Loureiro 1793

Cycas revoluta var. *inermis* (de Loureiro) Miquel 1848, *C. siamensis* subsp. *inermis* (de Loureiro) J. Schuster 1932

The epithet for *Cycas inermis* is Latin for unarmed, referring to the generally spine-free petiole. **Stems** arborescent, usually unbranched, 1–1.5 m (3.5–4.9 ft) tall, to 25 cm (10 in) in diameter, apex densely red-brown tomentose. **Leaves** numerous, upright, about 1.5 m (4.9 ft) long and 25 cm (10 in) wide. Petiole unarmed, subterete, about 22.5 cm (8.9 in) long. Leaflets numerous, crowded, linear lanceolate with a pungent apex, subfalcate, lighter below than above, persistently tomentose on the underside in the area of the midrib, upper and lower leaflets reduced in length, the lower ones generally two-lobed with the divisions widely spread, median leaflets 15–18.8 cm (6–7.4 in) long, 4–6 mm (to 0.2 in) wide, margins revolute flat or undulate, the lower one shortly decurrent. **Female cones** closed type. Sporophylls with two to six tomentose ovules just below the lamina. Lamina broad oblong, thick, densely yellow-brown tomentose, the spinelike divisions spreading almost at right angles from its main axis. Sarcotesta slightly tomentose in the juvenile stage, glabrous and yellow-orange when mature. Sclerotesta distinctly pointed at the attachment end, otherwise ovoid. **Male cones** solitary, erect, ovoid oblong, 23–30 cm (9–12 in) long, 8 cm (3.2 in) in diameter, widest at the base and tapering toward the apex, finely rusty tomentose. Sporophylls wedge shaped, 25–35 mm (1–1.4 in) long. Sporophyll face deltoid, 7–10 mm (0.3–0.4 in) high, 16–29 mm (0.6–1.1 in) wide, the upper half drawn out into a short, slender tip. **Habitat:** Reported to occur in low-elevation, semideciduous tropical forests. **Distribution:** Vietnam, area of Ho Chi Minh City (Saigon).

Cycas inermis was described in 1793 by João de Loureiro and is one of the earliest named species of the genus. Through the years it has come under attack as to whether or not it is distinct. Friedrich Anton Wilhelm Miquel (1843b) wrote of it, and in his opinion it was distinct. However, he later placed it under *C. revoluta.* In 1868 Cornelius Oudemans examined the seeds and sporophylls of *C. inermis* and *C. revoluta* and decided that the species were distinct. The habitats of the two are separated by more than 1900 km (1200 miles), so it would seem reasonable to believe that they are distinct. Besides the spatial separation there are differences in petiole, female sporophyll, seed shape, and the prevalence of divided leaflets in *C. inermis.* There is no doubt that *C. inermis* and *C. revoluta* are closely related, as evidenced by their tomentose ovules, a condition separating them from most other species of the genus. The paucity of material in cultivation makes it very difficult to compare the two properly.

It has been suggested that because of its divided leaflets and its occurrence within the same country, *Cycas inermis* may be related to *C. micholitzii.* The few small, basal, divided leaflets in *C. inermis,* however, are in no way similar to those of *C. micholitzii. Cycas micholitzii* is a subterranean stemmed cycad with long, upright leaves and broad, flat leaflets divided one to three times. Taking all of features into consideration, it is obvious that *C. inermis* has no close relationship to *C. micholitzii.*

Not a great deal is known regarding the habitat of *Cycas inermis* or its response to cultivation. The habitat has been described as low-elevation, semideciduous, tropical forest, and possibly grassland. It seems reasonable to believe that the cultivation of *C. inermis* should be no different from that of other species native to similar habitats. The opportunity to study *C. inermis* in its habitat may once again become possible. This would no doubt add greatly to our knowledge of this cycad.

No data are available as to the conservation status of *Cycas inermis*. Because of continuing habitat destruction, it should be considered threatened until proven otherwise.

Cycas javana (Miquel) de Laubenfels in de Laubenfels & Adema 1998

Cycas circinalis var. *javana* Miquel 1842

The epithet for *Cycas javana* refers to Java, Indonesia, the site of the initial collection of this cycad. Stems arborescent, to 6 m (19.7 ft) long, 25–40 cm (10–16 in) in diameter, often swollen at the base. Cataphylls linear, soft, lightly pubescent, articulated, 7–8 cm (2.8–3.2 in) long, 2–2.5 cm (0.8–1 in) wide. Leaves erect, then spreading, straight, glossy bright green, terminated by a spine or paired leaflets, 2–2.6 m (6.6–8.5 ft) long, 48–74 cm (19–29 in) wide, flat, the juvenile leaves densely brown tomentose, becoming glabrous with age. Petiole 40–90 cm (16–35 in) long, glabrous, armed 40–90% of its length. Leaflets in 65–85 pairs, spreading, leathery, often falcate, glossy bright green above, dull light green below, flat, straight, median leaflets 24–37 cm (9.5–15 in) long, 1–1.5 cm (0.4–0.6 in) wide, midrib prominent above and below, margin slightly revolute. Female cones open type. Sporophylls 24–36 cm (9.5–14 in) long, each with two to six glabrous ovules. Lamina lanceolate, 60–95 mm (2.4–3.7 in) long, 11–21 mm (0.4–0.8 in) wide, regularly toothed, with 12–30 lateral spines 1–2 mm long, apical spine distinct, 1–3 cm (0.4–1.2 in) long, 1.5–3 mm wide at its base. Sarcotesta yellow to orange. Sclerotesta smooth, globose, 4.5–6 cm (1.8–2.4 in) long, 3.5–6 cm (1.4–2.4 in) in diameter. Male cones solitary, ovoid, 30–70 cm (12–28 in) long, 12–17 cm (4.7–6.7 in) in diameter. Peduncle 2–3 cm (0.8–1.2 in) long. Sporophylls 4–4.5 cm (1.6–1.8 in) long, about 1.5 cm (0.6 in) wide, apical spine extending 5–7 mm (0.2–0.3 in) out from the sporophyll face, then sharply angled upward 10–15 mm (0.4–0.6 in). Habitat: Understory of lowland rain forest. Distribution: Indonesia, islands of Sumatra, and Java.

Cycas javana was originally described in 1842 by Friedrich Anton Wilhelm Miquel as *C. circinalis* var. *javana*. It was not until the mid-1990s that it was elevated to the rank of species, by David de Laubenfels. This species is still not well known or well represented in herbaria or botanical gardens. As true for a number of other species in the genus, *C. javana* is in need of detailed field investigation. The closest relatives of *Cycas javana* are thought to be *C. edentata* and *C. silvestris* because of their similarity in leaf and stem, but when cones are present they are said to be easily separated. Both these other species also occur on or near Java.

Cycas javana is rarely encountered in collections, thus its cultivation requirements are not known. Judging by its habitat, we can be reasonably certain that it will require subtropical to tropical growing conditions and frequent watering. The conservation status of *Cycas javana* is impossible to ascertain because of the lack of information on its distribution and insufficient field data.

Cycas lane-poolei C. A. Gardner 1923

PLATES 138, 139

Cycas lane-poolei is named in honor of Charles Edward Lane-Poole (1885–1970), conservator of forests for Western Australia, 1916–1926. Stems arborescent, erect, sometimes branched due to injury, 5.5–8 m (18–26 ft) tall, 10–15 cm (4–6 in) in diameter. Cataphylls linear, pungent, 6–10 cm (2.4–3.9 in) long. Leaves numerous, curved backward and downward, 0.6–1.1 m (2–3.6 ft) long, flat to slightly keeled, slightly drooping, glaucous green when fresh, bright green when mature, emergent leaves sparsely tomentose, becoming glabrous when mature. Petiole 18–40 cm (7.1–16 in) long, 6–11 mm (0.2–0.4 in) in diameter, unarmed or fully armed with short stout spines. Leaflets in 45–85 pairs, spaced 4–12 mm (to 0.5 in) apart, angled forward 45–60°, basal leaflets not reduced to spines, median leaflets 6–17 cm (2.4–6.7 in) long, 5–9 mm (0.2–0.4 in) wide, midrib raised above and below, margin flat, decurrent to next leaflet below in the upper half of the leaf, not decurrent or only slightly so in the lower portion of the leaf. Female cones open type. Sporophylls 16–22 cm (6.3–8.7 in) long, 12 mm (0.5 in) wide, lightly red-brown tomentose when emergent, glabrous when mature, each with two to four ovules slightly above the middle. Lamina lanceolate to triangular, 40–65 mm (1.6–2.6 in) long, 17–28 mm (0.7–1.1 in) wide, with one or two basal lobes and regularly toothed, with 12–30 lateral spines 1–5 mm (to 0.2 in) long, 1–2 mm wide, apical spine 15–20 mm (0.6–0.8 in) long. Sarcotesta yellowish brown and slightly glaucous when ripe.

Sclerotesta subglobose, 31–45 mm (1.2–1.8 in) long, 27–40 mm (1.1–1.6 in) in diameter, tan, the surface shallowly fissured. **Male cones** solitary, ovoid, erect until the pollen is shed, 10–18 cm (4–7.1 in) long, 9–11 cm (3.5–4.3 in) in diameter, lightly covered with a reddish brown tomentum. Peduncle short, cone appearing sessile. Sporophylls 25–35 mm (1–1.4 in) long. Sporophyll face 14–16 mm (0.6 in) wide, apical spine upright, 8–11 mm (0.3–0.4 in) long. **Habitat:** Flat or gently sloping areas composed of sandy soil, under open *Eucalyptus* woodland with *Livistona eastonii* at elevations of 300–370 m (980–1200 ft). Rainfall averages 1000 mm (40 in) annually, mostly falling in summer. Summer high temperatures are 36°C (97°F), winter lows 19°C (66°F). The climate is tropical with hot, wet summers and long, dry winters. **Distribution:** Australia, Western Australia, Kimberley district, northeast of Mount Hann and near the source of the Moran River.

Cycas lane-poolei was first reported by Frederick Slade Drake-Brockman, surveyor general for the Western Australian Department of Lands and Surveys, while leading the Exploration Expedition of 1901. During the Kimberley Exploration Expedition of 1921, Charles A. Gardner rediscovered the cycad, which he described in 1923. John R. Maconochie placed *C. lane-poolei* in synonymy under *C. armstrongii* in 1980, and finally in 1996, Kenneth D. Hill reinstated *C. lane-poolei* to species status where it rightfully belongs.

The remote habitat of *Cycas lane-poolei* on the Mitchell Plateau has restricted its collection for many years. Because of this, *C. lane-poolei* is generally not well represented in collections. In addition, *C. lane-poolei* has been considered by some researchers synonymous with *C. armstrongii,* specimens of which are much easier to acquire. There is no doubt that the closest relatives of *C. lane-poolei* are *C. armstrongii* and *C. conferta,* both of which are restricted to the Northern Territory. The growth habits of these three cycads show several similarities. All three are usually deciduous, they produce relatively tall, slender trunks, and their leaves are somewhat similar in shape and size. Their habitat is generally in open *Eucalyptus* woodland with the terrain flat or gently rising. After personally investigating these three cycads in habitat, I have no doubt that they are all distinct species. A population of cycads has been discovered on the southern Mitchell Plateau that appears to be intermediate between *C. lane-poolei* and *C. basaltica.* Additional investigation will be required to decide if it is an undescribed species.

Since *Cycas lane-poolei* is not common in collections, it is difficult to assess its cultivation requirements. I would, however, expect them to be similar to those of *C. armstrongii.* This would call for a tropical climate with summer rainfall. In its habitat, *C. lane-poolei* generally goes somewhat dormant in the dry winter season. During this time it becomes deciduous, and all leaves dry and break away cleanly from the crown. New leaves emerge again after the start of the summer rains. I have been told that in cultivation, where water is provided year-round, *C. lane-poolei* is not deciduous.

Propagation is simple from seed, taking 4–6 months to germinate. As with other species of *Cycas* from areas with extreme dry periods, a long taproot is grown before the first leaf is produced. The seedlings have strongly contractile roots that pull the crown of the plant into the soil. This no doubt provides protection from grass fires and drought. Given proper conditions, growth is rapid. Seedlings cultivated outside Australia can be difficult, as many develop crown rot. This problem does not seem to be widespread in Australia.

Cycas lane-poolei can be considered as not threatened. Because of its remote habitat, *C. lane-poolei* is well insulated from human civilization. It was not until the 1980s that seed collectors rediscovered the population and began to harvest seed, but *C. lane-poolei* does not seem to be threatened. It is difficult to ascertain the size of populations because of their scattered distribution. Regeneration is acceptable for a slowly growing plant, and juveniles are not uncommon in habitat.

Cycas lindstromii S. L. Yang, K. D. Hill & N. T. Hiep 1997

PLATES 140, 141

Epicycas lindstromii (S. L. Yang, K. D. Hill & N. T. Hiep) de Laubenfels in de Laubenfels & Adema 1998

Cycas lindstromii is named in honor of Anders Lindstrom, cycad enthusiast from Stockholm, Sweden, who assisted in the discovery of this species. **Stems** subterranean, often branched at the apex, swollen at the base, 15–23 cm (6–9.1 in) long, 13–25 cm (5.1–10 in) in diameter, the epidermis white to gray, and smooth. Cataphylls brown tomentose, soft, narrowly triangular, 2–5 cm (0.8–2 in) long, 3–7 mm (to 0.3 in) wide at the base. **Leaves** usually 2–12, spreading, very glossy, bright green above, yellowish green below, 0.5–1 m (1.6–3.3 ft) long, moderately keeled. Petiole 15–35 cm (6–14 in) long, glabrous, spiny 50–100% of its length. Leaflets in 9–30 pairs, angled forward 40–60°, flat, simple, glabrous, crowded and overlapping, spaced 7–12 mm (0.3–0.5 in) apart, basal leaflets not reduced to spines but sometimes forked, 3.5–12 cm (1.4–4.7 in) long, median leaflets 10–17 cm (4–6.7 in) long, 7–10 mm (0.3–0.4 in) wide, margins flat, the lower one decurrent for 3–5 mm (to 0.2 in), apex acute. **Female cones** closed type, about 12 cm (4.7 in) high, 7–9 cm (2.8–3.5 in) in diameter. Sporophylls 8–17 cm (3.2–6.7 in) long, each with two to four glabrous ovules. Lamina ovate, 5.5–10 cm (2.2–3.9 in) long, 1.5–3 cm (0.6–1.2 in) wide, deeply pectinate, with 6–13 pairs of soft lateral spines 8–12 mm (0.3–0.5 in) long, 2–3 mm wide, apical spine distinct, 10–30 mm (0.4–1.2 in) long, 2–4 mm wide at its base. Sarcotesta orange and not glaucous when ripe. Sclerotesta ovoid, 31–35 mm (1.2–1.4 in) long, 20–33 mm (0.8–1.3 in) in diameter, smooth. **Male cones** solitary to each crown, erect, spindle shaped, 16–20 cm (6.3–8 in) long, 4–5 cm (1.6–2 in) in diameter, yellow. Peduncle about 3 cm (1.2 in) long. Sporophylls 10–16 mm (0.4–0.6 in) long, the upper surface with a prominent central ridge from its attachment to the sporophyll face. Sporophyll face 8–15 mm (0.3–0.6 in) wide, projecting 3–4 mm, apical spine rudimentary, sharply upturned, 2–8 mm (to 0.3 in) long. Sporangia in a single patch. **Habitat:** Sandy grassland and dry open forest near the coast from sea level to 30 m (100 ft). **Distribution:** Vietnam, southern part of the country in Bà Ria, Bình Thuân, and Thuân Hai provinces.

Cycas lindstromii was described in 1997 after field studies made by S. L. Yang in southern Vietnam. It is an unusual species because of its dwarf habit, branching apex, and habitat preference. Unlike most of the other species of the genus, *C. lindstromii* favors arid coastal areas, where it grows in grassland and dry open forest at low elevations in almost pure sand. Its habit of branching at the apex to form clumps is reminiscent of *Zamia furfuracea* of Veracruz, Mexico, which is also found in coastal habitats.

Cycas lindstromii has been placed by Yang, Kenneth D. Hill, and N. T. Hiep in section *Indosinenses* of the genus. Within this section, *C. lindstromii* and *C. siamensis* make up subsection *Indosinenses,* defined by the small, narrow male cones and the overall short stature. *Cycas lindstromii* differs from *C. siamensis* in its subterranean and frequently branched stem, shorter keeled leaves with basal leaflets not reduced to spines, narrower male cones, and relatively narrower, more elongated megasporophyll lamina.

Outside Vietnam, nothing is known of the cultivation requirements of *Cycas lindstromii.* It has become a locally popular garden subject and pot plant in Vietnam, and this popularity has led to the removal of large numbers of the cycad from its habitat. Because of its small size and handsome appearance, *C. lindstromii* would no doubt become a popular plant wherever it could be grown. It would probably require a tropical climate or at least a frost-free location. It is hoped that seed will become available so that this remarkable little cycad can become established horticulturally.

Cycas lindstromii must be considered severely threatened. This is the result of the extensive collecting from its habitat for commercial purposes, and also land clearance. If collection of this species from the wild continues unrestricted, *C. lindstromii* may soon be under the threat of extinction.

Cycas litoralis K. D. Hill 1999b

PLATE 142

The epithet for *Cycas litoralis* is Latin, pertaining to the seashore and referring to this cycad's coastal habitat. **Stems** arborescent, erect, 3–10 m (10–33 ft) tall, 11–20 cm (4.3–8 in) in diameter. Cataphylls broadly triangular, soft, densely gray to yellow-brown tomentose, 4–7 cm (1.6–2.8 in) long. **Leaves** numerous, spreading, glossy bright green, 1.5–2.5 m (4.9–8.2 ft) long, 44–64 cm (17–25 in) wide, flat. Petiole 50–90 cm (20–36 in) long (20–35% of total leaf length), glabrous, armed with spines 80–100% of its length. Leaflets simple, glabrous, much lighter below than above, angled forward 70–85°, spaced 15–35 mm (0.6–1.4 in) apart, apex acute but without a spine, basal leaflets not reduced to spines and averaging 19 cm (7.5 in) long, median leaflets 26–35 cm (10–14 in) long, 14–19 mm (0.6–0.7 in) wide, midrib flat above, raised below, margins curved slightly backward and downward, the lower one decurrent for 5–8 mm (0.2–0.3 in). **Female cones** open type. Sporophylls 30–50 cm (12–20 in) long, densely white or yellow tomentose, each with four to eight glabrous ovules. Lamina lanceolate, 9–12 cm (3.5–4.7 in) long, 2.5–3.5 cm (1–1.4 in) wide, obscurely toothed, with 6–14 soft, indistinct lateral spines to 1 mm long, apical spine distinct, 25–40 mm (1–1.6 in) long, 5–8 mm (0.2–0.3 in) wide at its base. Sarcotesta orange-brown when ripe. Sclerotesta flattened ovoid, 45–52 mm (1.8–2 in) long, 30–43 mm (1.2–1.7 in) wide, with an apical crest, smooth, interior spongy layer present. **Male cones** solitary, ovoid, 16–40 cm (6.3–16 in) long, 9–12 cm (3.5–4.7 in) in diameter, orange tomentose. Peduncle short, cone appearing sessile. Sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face 18–22 mm (0.7–0.9 in) wide, apical spine prominent, sharply upturned, 9–17 mm (0.4–0.7 in) long. **Habitat:** Only along shorelines in full sun to moderate shade, in dry littoral scrub on beach sand or on rocky headlands, often in shallow soil over both granite and limestone. **Distribution:** Vietnam, southern part of the country, to southern Thailand, southern Myanmar (Burma), and south into peninsular Malaysia, and Sumatra, but apparently not elsewhere in Malaysia or Indonesia.

Although *Cycas litoralis* was known for many years but mistakenly identified as *C. circinalis* or *C. rumphii*; it was recognized as undescribed, and described by Kenneth D. Hill in 1999. The nonpectinate megasporophyll and large seed with its spongy endocarp place *C. litoralis* in the *C. rumphii* group. Within this group it is distinguished from *C. rumphii* and all related species occurring to the south and east by the distinct, stout spine that terminates the microsporophyll face. In Madagascar, *C. thouarsii* has similar microsporophylls but has emergent leaves distinctly glaucous, and narrower leaflets.

Cycas litoralis has not been commonly grown as a garden plant except in Thailand. It can be frequently seen in gardens near areas where it occurs naturally. In cultivation it forms handsome plants that are a fine addition to any landscape. As with several of the larger species of the genus, *C. litoralis* does not have any distinctive visual features separating it from other similar ones. It is suitable for tropical to subtropical climates, possibly for milder areas of temperate regions.

Cycas litoralis was once abundant and widespread, occurring commonly in coastal areas. These coastal sites have experienced severe pressures from human population increase and development. Although *C. litoralis* is not threatened, it is potentially vulnerable in the long term.

Cycas maconochiei Chirgwin & K. D. Hill 1996

PLATE 143

Cycas maconochiei, named in honor of John R. Maconochie (1941–1984), who was working on a revision of *Cycas* in Australia until his untimely death brought his research to an end, is called Fog Bay cycas, Cox Peninsula cycas, and Bynoe Harbor cycas. Three subspecies of *C. maconochiei* are recognized: *maconochiei* (described here), *lanata,* and *viridis.* **Stems** arborescent, erect, usually 1 m (3.3 ft) tall to a maximum height of 5 m (16 ft), 9–10 cm (3.5–4 in) in diameter. **Leaves** numerous, 1–1.5 m (3.3–4.9 ft) long, 21 cm (8.3 in) wide, flat, sometimes slightly twisted, emerging leaves densely white tomentose, the tomentum persistent for a long time, especially at the base and underside of leaflets. Leaves may be deciduous during the dry season. Petiole fully or partially armed, sometimes unarmed, 30–33 cm (12–13 in) long. Leaflets in 108–113 pairs, straight or slightly falcate, drooping, linear, almost at right angles to the rachis, gray-green, median leaflets 13–15 cm (5.1–6 in) long, 5–8 mm (0.2–0.3 in) wide, midrib depressed above, prominent below, margin slightly revolute or flat. **Female cones** open type. Sporophylls 20–29 cm (8–11 in) long, red-brown tomentose, each with two to four ovules. Lamina lanceolate, 40–65 mm (1.6–2.6 in) long, 14–25 mm (0.6–1 in) wide, regularly toothed, with 20–36 lateral spines 1–4 mm long, apical spine 10–20 mm (0.4–0.8 in) long. Sarcotesta ovoid to globose, glabrous, turning orange when ripe. Sclerotesta ovoid or globose except for the somewhat pointed chalaza, 30–35 mm (1.2–1.4 in) long, 24–30 mm (0.9–1.2 in) in diameter, more or less smooth. **Male cones** solitary, erect, ovoid to long ovoid, 21–34 cm (8.3–13 in) long, 10–14 cm (4–5.5 in) in diameter, light to medium brown tomentose. **Habitat:** Open tropical woodland in association with *Eucalyptus, Grevillea, Pandanus,* and *Planchonia. Cycas maconochiei* may be the dominant plant. The habitat is generally very flat, from sea level to 40 m (130 ft), with soil composed of red sandy clay. Rainfall averages 1500 mm (59 in) annually, falling mainly in summer. Temperatures average 20–30°C (68–86°F) summer and winter. **Distribution:** Australia, Northern Territory, between Fog Bay and Port Darwin to the southwest of Darwin.

The cycad now known as *Cycas maconochiei* was originally reported in the early 1980s. I first saw it in 1984 when George Brown, then director of the Darwin Botanic Garden, took me to the Cox Peninsula area. *Cycas maconochiei* is a distinctive cycad with flat, glaucous gray leaves that grows in some areas with *C. armstrongii.* A number of obvious hybrids between the two were seen, with characteristics halfway between the two parents. *Cycas maconochiei* is the dominant cycad in the Cox Peninsula area and is reported to occur in large numbers on both sides of Bynoe Harbor. Monty Anderson wrote the following to me in 1985:

> You will be interested to know that the Bynoe *Cycas* has a much greater range than what you saw when you were here. The station on the other side of Bynoe Harbor was sold recently and the public now has access. There are extensive stands of the *Cycas* all along the coast, almost to the mouth of the Daly River, and up to 20 km (12 mi[les]) inland. You may remember that in the stand you saw there were many plants that were obvious crosses with *C. armstrongii.* On the other side there are no crosses, the plants are very uniform in their characteristics. The plants are ex-

tremely numerous, and some of the stands run continuously for many miles.

In cultivation outside its native area, *Cycas maconochiei* is difficult to grow. Crown rot in the seedlings has been almost impossible to control, and most seedlings die from this cause. It may be that deeper pots and less watering would make a difference. In time, I am sure that the proper combination of soil depth, water, and fertilizer will be found. The conservation status of *C. maconochiei* seems very secure as there are many thousands of plants scattered over an extensive area, and regeneration is prolific.

Cycas maconochiei subsp. *lanata* K. D. Hill 1996

The subspecific epithet for *Cycas maconochiei* subsp. *lanata* is derived from *lanatus,* Latin for woolly, probably referring to the woolly crown and emergent leaves. **Stems** to 3 m (10 ft) long, rarely as long as 7 m (23 ft), 9–14 cm (3.5–5.5 in) in diameter. **Leaves** numerous, spreading, 0.7–1.2 m (2.3–3.9 ft) long, moderately keeled. Petiole 18–33 cm (7.1–13 in) long and armed 10–100% of its length. Leaflets in 80–115 pairs, orange-tomentose and slightly glaucous when new, becoming dull to semiglossy glaucous green, median leaflets 9–15 cm (3.5–6 in) long, 4–5 mm (0.2 in) wide, margin curved backward and downward. **Female cones** open type. Sporophylls 23–27 cm (9.1–11 in) long. Lamina 50–60 mm (2–2.4 in) long, 14–20 mm (0.6–0.8 in) wide, with 20–30 lateral teeth, apical spine 10–15 mm (0.4–0.6 in) long. Sclerotesta 30–35 mm (1.2–1.4 in) long, 27–32 mm (1.1–1.3 in) in diameter. **Male cones** erect, 22–33 cm (8.7–13 in) long, 11–14 cm (4.3–5.5 in) in diameter. **Habitat:** Savanna woodland or forest dominated by *Eucalyptus miniata* and *E. tetrodonta,* on sandy soils. **Distribution:** Australia, Northern Territory, from the northern Wingate Mountains and adjacent plains country to the north and west, extending to the coast north of Peppimenarti, west almost to Port Keats.

Cycas maconochiei subsp. *lanata* is distinguished from subspecies *maconochiei* and *viridis* by its narrow leaflets and margins that are curved over backward and downward.

Cycas maconochiei subsp. *viridis* K. D. Hill 1996

The subspecific epithet for *Cycas maconochiei* subsp. *viridis* is Latin for green, referring to the color of the leaves. **Stems** to 4 m (13 ft) long, rarely as long as 6 m (20 ft), 12–16 cm (4.7–6.3 in) in diameter. **Leaves** numerous, spreading, 0.8–1.2 m (2.6–3.9 ft) long, moderately keeled. Petiole 15–26 cm (6–10 in) long, either unarmed or spiny as much as 90% of its length. Leaflets in 80–150 pairs, orange-tomentose and slightly glaucous when new, becoming glabrous, glossy medium to deep green when mature, angled forward 60–80°, median leaflets 8.5–17 cm (3.3–6.7 in) long, 4–6 mm (0.2 in) wide, margin curved backward and downward. **Female cones** open type. Sporophylls 22–29 cm (8.7–11 in) long. Lamina 45–65 mm (1.8–2.6 in) long, 17–24 mm (0.7–0.9 in) wide, with 24–32 lateral teeth, apical spine 1–2 cm (0.4–0.8 in) long. Sarcotesta not glaucous, orange when ripe. Sclerotesta 34–36 mm (1.3–1.4 in) long, 30–32 mm (1.2–1.3 in) in diameter. **Male cones** not described. **Habitat:** Open woodland on sandy soils over sandstone or on old beach sands. **Distribution:** Australia, Northern Territory, known only from around Fossil Head.

Cycas maconochiei subsp. *viridis* is distinguished from subspecies *maconochiei* and *lanata* by its relatively broader, flatter leaflets, which are glossy green.

Cycas macrocarpa W. Griffith 1854

PLATES 144, 145

The epithet for *Cycas macrocarpa* is derived from *macros,* Greek for large, and *carpos,* fruit, referring to the large seeds. **Stems** arborescent, erect, to 12 m (39 ft) long, 25–75 cm (10–30 in) in diameter, the bark gray and often lightly fissured. Cataphylls narrowly triangular, pungent, 7–17 cm (2.8–6.7 in) long. **Leaves** numerous, spreading, very glossy deep green, 2.5–3.5 m (8–11.5 ft) long, 76–88 cm (30–35 in) wide, more or less flat, usually terminated by paired leaflets. Petiole 55–75 cm (22–30 in) long, armed with 8–16 pairs of spines spaced 3–3.5 cm (1.2–1.4 in) apart. Leaflets in 90–112 pairs, subfalcate, flat, dark green above, lighter below, angled forward 65–85°, spaced 15–35 mm (0.6–1.4 in) apart, basal leaflets not reduced to spines, median leaflets 24–45 cm (9.4–18 in) long, 13–21 mm (0.5–0.8 in) wide, midrib raised above and below, margin flat to curved slightly backward and downward, often undulate, decurrent for 5–12 mm (0.2–0.5 in). **Female cones** open type. Sporophylls 10–21 cm (4–8.3 in) long, densely orange-brown tomentose, each with two to four glabrous ovules. Lamina lanceolate, 50–70 mm (2–2.8 in) long, 17–35 mm (0.7–1.4 in) wide, margin shallowly pectinate, with 10–22 lateral spines 5–17 mm (0.2–0.7) long, 1–2 mm wide, apical spine distinct, 17–45 mm (0.7–1.8 in) long, 2–7 mm (to 0.3 in) wide at its base. Sarcotesta yellow when ripe. Sclerotesta long ovoid to oblong, 45–53 mm (1.8–2.1 in) long, 35–42 mm (1.4–1.7 in) in diameter, smooth. **Male cones** solitary, erect, ovoid, 16–22 cm (6.3–8.7 in) long, 9–12 cm (3.5–4.7 in) in diameter, densely orange-brown tomentose. Sporophylls 24–29 mm (0.9–1.1 in) long. Sporophyll face 14–20 mm (0.6–0.8 in) wide, apical spine rudimentary to prominent, sharply erect, 9–11 mm (0.4 in) long. Sporangia in a single patch. **Habitat:** Low-elevation rain forest in deep shade on well-drained sandy clay loam soils, preferring ridges or hills. **Distribution:** Thailand, southern part of the country, south to central peninsular Malaysia.

Cycas macrocarpa was discovered by William Griffith (1810–1845), a British colonial physician with the East India Company, later a botanist, then superintendent of the Calcutta Botanic Garden. Griffith did not publish a description while he was alive and his work was left to the East India Company. It was later compiled by John M'Clelland and published by the colonial government of Bengal in Calcutta in 1854. Although the publication of *C. macrocarpa* was valid in every respect, subsequent botanists dealing with the cycads largely ignored it. Both Friedrich Anton Wilhelm Miquel and Alphonse de Candolle considered *C. macrocarpa* a doubtful species and submerged it into either *C. rumphii* or *C. circinalis.* It was not until the 1990s that Kenneth D. Hill of the National Herbarium of New South Wales, Australia, during a visit to southern Thailand, was shown some cycads near the Malaysian border. After considerable research these plants were identified as the long-lost and forgotten *C. macrocarpa.*

Cycas macrocarpa is a handsome cycad, similar in some respects to *C. rumphii* though it is not closely related to that species, as evidenced by its lack of a spongy flotation layer in the seed. In Thailand and Malaysia, *C. macrocarpa* is often used as an ornamental and can be seen gracing gardens in its general area of occurrence. It grows rapidly from seed and requires a tropical to subtropical climate for best appearance. *Cycas macrocarpa* is rare in collections because seed is rarely collected.

The conservation status of *Cycas macrocarpa* is good. Even though it is scarce in cultivation outside its native countries, it is fairly common in the ridge forests of southern Thailand and peninsular Malaysia. In spite of the fact that many hundreds of these cycads have been destroyed through land clearance for agriculture, it still occurs in large numbers, though often widely scattered.

Cycas media R. Brown 1810

PLATES 22, 146, 147

Cycas gracilis Miquel 1863
Cycas normanbyana F. Mueller 1874, *C. rumphii* subsp. *normanbyana* (F. Mueller) J. Schuster 1932
Cycas gracilis var. *glauca* Regel 1876b
Cycas gracilis var. *viridis* Regel 1876b
Cycas kennedyana F. Mueller 1882

The epithet for *Cycas media* is derived from *medius,* Latin for middle. Robert Brown may have meant it to mean midway between the other two species he named in the same publication, *C. angulata* and *C. thouarsii.* Three subspecies of *C. media* are recognized: *media* (described here), *banksii,* and *ensata.* **Stems** arborescent, erect, usually unbranched except when injured, 1–3 m (3.3–10 ft) tall, rarely as tall as 6–8 m (20–26 ft), and generally 20–30 cm (8–12 in) in diameter. Cataphylls 6–9 cm (2.4–3.5 in) long. **Leaves** generally 10–30 in a mature plant, dark green, 0.7–1.8 m (2.3–5.9 ft) long, 20–26 cm (8–10 in) wide, slightly keeled and gently arching. Petiole usually about 20 cm (8 in) long, rounded above and below, densely tomentose with short reddish hairs that gradually weather away, base abruptly spreading and persistently tomentose, completely armed or unarmed, dependent mainly on the age of the plant, the older and larger the plant, the fewer spines on the petiole, the spines when present 3–6 mm (to 0.2 in) long and very sharp. Leaflets in 60–100 pairs, straight to falcate, flat to slightly concave, apex either gradually or abruptly acuminate, median leaflets 13–21 cm (5.1–8.3 in) long, 6–8 mm (0.2–0.3 in) wide, at the attachment constricted above almost to the midrib and decurrent below to the next leaflet, margins flat or slightly revolute. **Female cones** open type. Sporophylls 20–37 cm (8–15 in) long, light yellowish brown, densely reddish brown tomentose, each with 4–10 ovules. Lamina narrowly triangular, 35–90 mm (1.4–3.5 in) long, 17–35 mm (0.7–1.4 in) wide, regularly toothed, with 18–32 lateral spines 4–10 mm (to 0.4 in) long, 1–3 mm wide, apical spine 15–40 mm (0.6–1.6 in) long. Sarcotesta glabrous, usually orange or brownish yellow when ripe. Sclerotesta ovoid to subglobose, 31–39 mm (1.2–1.5 in) long, 26–35 mm (1–1.4 in) in diameter, light tan, smooth. **Male cones** solitary, ovoid to ovoid cylindrical, 15–30 cm (6–12 in) long, 8–15 cm (3.2–6 in) in diameter, orange tomentose. Peduncle very short, cone appearing almost sessile. Sporophylls wedge shaped, 25–33 mm (1–1.3 in) long. Sporophyll face 8–12 mm (0.3–0.5 in) wide, densely tomentose, apical spine erect, 6–10 mm (0.2–0.4 in) long. Sporangia covering the entire lower surface except for a sterile notch at the apex. **Habitat:** Open tropical woodland or occasionally on the margins of rain forest, usually on rocky soils. A western exposure seems to be preferred, from near sea level to about 860 m (2800 ft). Rainfall averages 1500–2000 mm (59–79 in) annually, falling mostly in summer. Summer temperatures average 20–30°C (68–86°F). **Distribution:** Australia, Queensland, coastal areas from St. Lawrence in the south to Cardwell in the north.

One of the earliest species of Australian cycads to be described, *Cycas media* was discovered by Robert Brown, who served as botanist on the voyage of the *Investigator* in 1801–1805, which was led by Matthew Flinders to New Holland, that is, Australia. The knowledge of *C. media* is even today vague enough to create controversy among taxonomists and collectors. The reason for this is the immense area of distribution attributed to *C. media* and the multitude of variations found within the range. In 1986 I drove from Brisbane to just short of Cooktown to survey populations of *Cycas,* to gain a better understanding of the various species, *C. media* in particular. During this trip so many forms of *C. media* were found that is was impossible to gain a clear concept of this variable and confusing species. In 1996, Kenneth D. Hill separated *C. media* into three subspecies: *media, banksii,* and *ensata.* Over its range, *C. media* is very common. It occurs in large colonies and can easily be seen from any of the coastal roads in Queensland from Rockhampton north. *Cycas media* is not restricted to coastal areas; it is also found inland in scattered colonies, each one displaying variations in morphology.

Cycas media is usually burned over each year, and the fires destroy the leaves and generally much of the seed crop. These fires blacken the trunks, but usually no permanent damage is done and the cycads rapidly produce new leaves and cones, soon looking as if nothing had happened. It appears that many of the Australian cycads, especially *C. media,* have a pattern of fire symbiosis. Cycads observed in areas where no fire has burned for several years look unhealthy and do not produce large crops of seed.

In the past, *Cycas media* served as a food item for the Aborigines. They collected seeds, roasted them in a fire, and left them in the ashes until the next day. The shells were then removed and the kernel ground into flour. The flour was then put into a dilley bag, a cloth sack, and left to wash in a running stream for another day before being eaten. This procedure was very important since all parts of the cycad contain toxins that must be removed before they are safe to eat. At one time, stems of *C. media* were harvested commercially for the production of starch.

In cultivation, *Cycas media* grows well except in areas of poor drainage and deep shade. In its native range, the *Cycas* leaf beetle (*Lilioceris nigripes*) can stunt young leaves of *C. media* (Plate 22). Seed germinates easily and will produce a sizable plant in a few years if given a rich soil and proper fertilization. This is one of the most cold tolerant of the Australian species of *Cycas,* and it can be grown even in the colder areas of southern Australia.

The conservation status of *Cycas media,* as this species is now defined, is very secure. Even though many hundreds of thousands have been eradicated from cattle land, it is still a common plant.

Cycas media subsp. *banksii* K. D. Hill 1996

The subspecific epithet of *Cycas media* subsp. *banksii* is named in honor of Joseph Banks (1743–1820), who accompanied James Cook, captain of the *Endeavour,* on the voyage of 1768–1771, during which many Australian plants were first collected. **Stems** with cataphylls, the largest 7–10 cm (2.8–4 in) long. **Leaves** 1–2 m (3.3–6.6 ft) long, median leaflets 13–24 cm (5.1–9.4 in) long, 8–10 mm (0.3–0.4 in) wide. **Female cones** open type. Sclerotesta 32–36 mm (1.3–1.4 in) long, 27–32 mm (1.1–1.3 in) in diameter. **Habitat:** Tall *Eucalyptus* forest in near-coastal sites. **Distribution:** Australia, Queensland, somewhat south of Cairns, north to north of Cooktown.

Cycas media subsp. *banksii* is distinguished from subspecies *media* and *ensata* by its shorter cataphylls and broader leaflets.

Cycas media subsp. *ensata* K. D. Hill 1996

The subspecific epithet of *Cycas media* subsp. *ensata* is derived from *ensatus,* Latin for swordlike, probably referring to the long, pointed cataphylls. **Stems** with cataphylls, the largest 10–12 cm (4–4.7 in) long. **Leaves** numerous, 1.4–2.3 m (4.6–7.5 ft) long, median leaflets 13–24 cm (5.1–9.4 in) long, 7–9 mm (0.3–0.4 in) wide. **Female cones** open type. Sclerotesta 33–36 mm (1.3–1.4 in) long, 29–32 mm (1.1–1.3 in) in diameter. **Habitat:** Coastal plains in flat country on deep alluvial sandy soils, under tall *Eucalyptus* forest or rain forest with *Livistona muelleri.* **Distribution:** Australia, Queensland, north of Silver Plains homestead, extending north to the Lockhart River.

Cycas media subsp. *ensata* is distinguished from subspecies *media* and *banksii* by its very long, hard, sharp cataphylls and relatively broad leaflets.

Cycas megacarpa K. D. Hill 1992

PLATE 148

Cycas megacarpa, the epithet derived from *megas,* Greek for very large, and *carpos,* fruit, referring to the distinctively large seeds, is called pine palm and zamia palm. **Stems** usually erect but sometimes slightly leaning in large, old specimens or those growing on steep slopes in shallow soil, generally to about 3 m (10 ft) tall, rarely as tall as 6 m (20 ft), 15–17.5 cm (6–7 in) in diameter. Cataphylls slender, orange-brown tomentose, to 7 cm (2.8 in) long. **Leaves** numerous, ascendant, arched to almost curved backward and downward, glaucous when newly emergent, gradually turning glossy green in about 12 months, the underside remaining glaucous, 0.8–1 m (2.6–3.3 ft) long, 23–30 cm (9.1–12 in) wide, slightly to strongly keeled, emergent leaves densely covered with gray to orange-brown tomentum. Petiole rounded above, keeled below, nearly glabrous, 15–36 cm (6–14 in) long, armed with a few spines 3 mm long just below the lowest leaflets. Leaflets in 60–135 pairs, spaced 5–12 mm (0.2–0.5 in) apart, broad linear, almost flat, acute at the apex, angled forward 40–70° except for the lower one to three pairs of downward-angled leaflets, basal leaflets about half the length of the median ones, not reduced to spines, median leaflets 12–20 cm (4.7–8 in) long, 5–8 mm (0.2–0.3 in) wide, midrib not raised or only slightly above, prominent below, margins straight and flat, the lower one decurrent for 2–3 mm. **Female cones** open type. Sporophylls long, open and loose, pendent, 14–25 cm (5.5–10 in) long, densely reddish brown and gray tomentose, each with usually two to four glabrous ovules. Lamina narrowly triangular, 40–70 mm (1.6–2.8 in) long, 15–32 mm (0.6–1.3 in) wide, lower margins serrate, the upper two-thirds with spines running parallel to the lamina, 6–13 mm (0.2–0.5 in) long and angled forward, apical spine 8–20 mm (0.3–0.8 in) long. Sarcotesta orange when ripe. Sclerotesta globose to ovoid, 37–42 mm (1.5–1.7 in) long, 31–37 mm (1.2–1.5 in) in diameter, light tan, the surface irregularly fissured. **Male cones** solitary, erect, oval ellipsoid, 16–18 cm (6.3–7.1 in) long, 7–10 cm (2.8–4 in) in diameter, densely orange-brown tomentose. Peduncle short, cone appearing sessile. Sporophylls narrowly wedge shaped, 30–33 mm (1.2–1.3 in) long. Sporophyll face 10–13 mm (0.4–0.5 in) wide, projecting about 7 mm (0.3 in), apical spine sharply upturned, 5–8 mm (0.2–0.3 in) long. **Habitat:** Open forest, usually on steep grassy hillsides in shallow rocky soil, commonly associated with *Eucalyptus, Xanthorrhoea,* and sometimes with *Macrozamia miquelii,* at elevations of 155–310 m (500–1000 ft). Rainfall averages 1500–2000 mm (59–79 in) annually, falling throughout the year but mainly in summer. Temperatures average 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Australia, Queensland, Mount Morgan, south to near Goomeri.

For many years *Cycas megacarpa* was misidentified as *C. kennedyana,* a species that has since been placed in synonymy under *C. media. Cycas megacarpa* can be easily distinguished from *C. media* by its thinner stems, its shorter, more strongly keeled leaves curved backward and downward, of a distinctive gray-green color, and its larger seeds with their irregularly fissured surface. *Cycas megacarpa* is fairly uniform over its range and can usually be quite easily identified by its distinctive features. The large, globose, irregularly fissured seeds are a good clue to the identity of this species. Plants in one stand in the Many Peak area seem to attain a much smaller size and have thinner stems. Their seeds are also smaller and do not show such distinctive fissuring on the sclerotesta. The smaller size, including the cones, would seem to indicate that this colony probably represents only a weakly or imperfectly developed form of *C. megacarpa.*

Cycas megacarpa is a very decorative cycad whose smaller size makes it a useful landscape plant. The slightly glaucous, strongly arching, keeled leaves make a striking and distinctive appearance. An established plant would do well in a water conservation garden as the species comes from a dry, sunny habitat. *Cycas megacarpa* has somewhat better frost tolerance than the other Australian species of the genus, which is not surprising as it is found farther south than any of the others. Cultivation is simple, and a wide range of soil, water, and light conditions is accepted without problems. As with most cycads, it requires well-drained soil to keep it in best condition. Regular applications of fertilizer through the growing season will cause the production of numerous leaves and enhance the glaucous color of the foliage. Seed is relatively easy to obtain and usually has a high percentage of viability.

The conservation status of *Cycas megacarpa* seems secure with many hundreds of plants in evidence at numerous locations. Without doubt, thousands of plants have been destroyed in past years to protect stock animals from eating the leaves. This fact is easily confirmed when one notes the large numbers of plants along the roadside in their habitat, whereas on the other side of the stock fences there are none to be seen. The awakening of nurseries and landscapers to the usefulness of cycads for decoration will no doubt create added pressure on those colonies remaining in the wild. It is hoped that this new awareness will encourage propagation of plants for commercial use from seed.

Cycas micholitzii Thiselton-Dyer 1905

PAGES 2–3, PLATES 149, 150

Epicycas micholitzii (Thiselton-Dyer) de Laubenfels in de Laubenfels & Adema 1998

Cycas micholitzii is named in honor of William Micholitz (1854–1932), discoverer of this cycad and a collector for Messrs. Sander and Sons, an English nursery of the early 1900s that first introduced *C. micholitzii* into cultivation. **Stems** subterranean or rarely emerging to 16 cm (6.3 in) above ground, unbranched, 30–40 cm (12–16 in) long, 4–24 cm (1.6–9.4 in) in diameter, the lower portions more or less smooth and tuberlike. Cataphylls short acuminate, gray-brown tomentose, deciduous, 3–5.5 cm (1.2–2.2 in) long, 6–8 cm (2.3–3.1 in) wide. **Leaves** usually one to three, rarely as many as six, erect with apex arched, 1.1–2.4 m (3.6–7.8 ft) long, about 50 cm (20 in) wide. Petiole 0.5–1 m (1.6–3.3 ft) long, armed 70–95% of its length with 60–80 pairs of spines 3–5 mm (to 0.2 in) long, spaced 3–4 cm (1.2–1.6 in) apart, terminating in a winged swollen base 4.5–8 cm (1.8–3.2 in) wide, the wings extending a short distance up the sides of the petiole as a membranous extension. Leaflets in 20–28 pairs in mature plants, spaced 3.5–6 cm (1.4–2.4 in) apart and at right angles to the erect rachis so as to place them one above the other, semiglossy to dull bright green, leathery to papery, median leaflets 23–36 cm (9–14 in) long, 1.1–1.9 cm (0.4–0.7 in) wide, apex acuminate, divided one or two times, juvenile plants with either simple lanceolate or once-divided leaflets but mature plants with dichotomous branching of the leaflets, ultimately forming two to four leaflet segments, petiolule 2–7 mm (to 0.3 in) long or almost lacking, midrib raised above, flat below, margins flat, the lower one weakly decurrent. **Female cones** closed type, 65–88 mm (2.6–3.5 in) high, 13–21 cm (5.1–8.3 in) in diameter, appearing at ground level. Sporophylls 10–12 cm (4–4.7 in) long, densely orange-yellow tomentose, each with four to six ovules. Lamina rhombic to obovate, 5–9 cm (2–3.5 in) long, 4.5–7 cm (1.8–2.8 in) wide, deeply pectinate with 7–11 pairs of spine-tipped, glabrous lobes 1.5–5 cm (0.6–2 in) long, apical spine 4–7 cm (1.6–2.8 in) long, 4–8 mm (to 0.3 in) wide. Sarcotesta yellow when ripe. Sclerotesta irregularly globose, slightly flattened, 19–23 mm (0.8–0.9 in) long, 16–18 mm (0.6–0.7 in) in diameter, covered with a fine netting of shallow grooves. **Male cones** solitary, erect, cylindrical, 15–25 cm (6–9.8 in) long, 3–5 cm (1.2–2 in) in diameter, narrowing toward the apex, golden yellow tomentose. Peduncle 30–35 mm (1.2–1.4 in) long, 15–17 mm (0.6–0.7 in) in diameter. Sporophylls 10–18 mm (0.4–0.7 in) long. Sporophyll face 8–10 mm (0.3–0.4 in) wide, projecting 7–9 mm (0.3–0.4 in), rounded or with a short acuminate spinelike apex 1–5 mm (to 0.2 in) long, generally yellow but with an orange margin. Sporangia in a single patch.

Habitat: Generally on limestone hills in neutral or slightly basic, deep, calcareous soils, in warm, moist, rain forest in semishaded areas on steep hillsides at elevations of 130–400 m (430–1300 ft). Rainfall averages 1350 mm (53 in) annually, three-quarters of it falling May–September. The climate is hot in summer and generally warm and frost-free in winter. **Distribution:** Vietnam, Annam Highlands in the central part of the country near the border with Laos.

In 1901 William Micholitz, collecting for Messrs. Sander and Sons in Annam, now part of Vietnam, discovered a *Cycas* with bifid leaflets near the border with Laos. Described in 1905, it (then including *C. rumphii* var. *bifida,* described from a collection made in 1899 and later considered a synonym of *C. multifrondis*) remained the only species of *Cycas* known to have divided leaflets until the 1990s when *C. multifrondis* (= *C. bifida*) and *C. multipinnata* were described, also with bifid leaflets.

Without doubt, *Cycas micholitzii* is one of the most distinctive and beautiful species of the genus. Reading the description of *C. micholitzii* in no way prepares one for the first sight of this cycad. The nearly invisible subterranean stem usually produces only one to three leaves, but the beauty of these leaves is hard to imagine. Mature leaves are erect and to 2.4 m (7.9 ft) tall. The broad leaflets divide one or two times, producing a final fan shape that is held at right angles to the rachis. The apex of each leaflet gracefully bends toward the ground. The leaflets are opposite each other, fan out over the ones below, and are about 30 cm (12 in) long. Each leaf therefore is approximately 50 cm (20 in) wide. The leaflets are dull bright green with prominently undulating margins and the overall aspect is breathtaking.

I have grown and studied several immature specimens of *Cycas micholitzii,* and their leaves were quite distinct from those of the adults. The seedling leaflets were flat, inserted into the rachis at right angles, and entire or less commonly once divided. The multiple division of the leaflets is a condition found only in mature plants.

During one of his expeditions in Asia, S. L. Yang collected *Cycas micholitzii* in Dong Lôm province in central Vietnam. He said that the plants he saw were generally smaller than *C. bifida* from northern Vietnam near the border with China. Electrophoretic studies show them as having major differences compared to *C. bifida.*

Cycas micholitzii is a dwarf, generally producing a completely subterranean stem. The contractile roots of *C. micholitzii* pull the stem into the ground, always keeping the crown at or slightly below soil level. This condition protects the stems from fires and most predators that might feed on them. In its habitat, *C. micholitzii* is found in rain forest in hot, humid conditions, inhabiting the steep sides of limestone hills under the tree canopy in moist, deep, calcareous soil.

It is sad to report that very few if any of the *Cycas micholitzii* plants introduced into cultivation in the early 1900s survived. Most of them were in botanical gardens and private collections in Europe and perished during World War II. *Cycas micholitzii* is not a difficult cycad to grow. On the contrary, there is no mention in the literature of any difficulty encountered in growing it. In my experience, the plants are strong, aggressive growers, rapidly increasing in size and strength. Plants no more than 25 mm (1 in) in diameter have grown to coning size in 3 years. We are starting to test *C. micholitzii* for cold tolerance but it will be several years until enough data are at hand to reach any conclusions. For the moment, *C. micholitzii* can be highly recommended for use in tropical to subtropical climatic areas, or as a greenhouse plant.

There are several botanical gardens in China with specimens of *Cycas micholitzii,* but elsewhere they are very rare. I have studied this species at the Guilin Botanic Garden, Guangxi, where there were about eight potted specimens. All were in fine condition and showed no distress. A few specimens have been introduced into cultivation outside China and seem to grow very well. Artificial propagation could increase the numbers of this beautiful cycad, and it is hoped that this will be done by those fortunate enough to have plants in cultivation. It has been reported that the seed of *C. micholitzii* is short-lived and should be planted soon after collection. Seedlings have simple leaves and would be difficult to identify based on leaves alone.

The conservation status of *Cycas micholitzii* is not good. By way of personal communication with S. L. Yang, I have been informed that a large portion of their habitat in Vietnam has been cleared.

Cycas micronesica K. D. Hill 1994b

PLATES 151, 152

Cycas micronesica, the epithet referring to Micronesia, islands where this cycad is endemic, is called *federico* in Guam. **Stems** erect, to 8 m (26 ft) tall, rarely as tall as 12 m (39 ft), 14–25 cm (5.5–10 in) in diameter. Cataphylls linear, 8–16 cm (3.2–6.3 in) long, the outer surface densely orange tomentose. **Leaves** numerous, 1.5–1.8 m (4.9–5.9 ft) long, flat, apex terminated with a spine about 4 mm long, emergent leaves densely and loosely tomentose with white and orange hairs, soon becoming glabrous. Petiole generally glabrous, 30–45 cm (12–18 in) long, usually unarmed, rarely armed as much as 20% of its length. Leaflets in 65–75 pairs, slightly bluish green when emergent, becoming glossy medium green when mature, much lighter below than above, median leaflets angled forward 70–80°, flat, 24–28 cm (9.4–11 in) long, 16–17 mm (0.6–0.7 in) wide, spaced 17–20 mm (0.7–0.8 in) apart, midrib not sharply raised and more or less equally prominent above and below, margins curved slightly backward and downward, the lower one decurrent for 7–10 mm (0.3–0.4 in). **Female cones** open type. Sporophylls 27–33 cm (11–13 in) long, gray and orange tomentose, each with two to six ovules. Lamina broadly ovate to elliptical, 45–55 mm (1.8–2.2 in) long, 35–45 mm (1.4–1.8 in) wide, regularly toothed, with 16–20 lateral spines 2–6 mm (to 0.2 in) long, apical spine 8–15 mm (0.3–0.6 in) long. Sarcotesta 3–6 mm (to 0.2 in) thick, orange when ripe. Sclerotesta ovoid to subglobose, flattened, 5–6 cm (2–2.4 in) long, 4.5–5 cm (1.8–2 in) in diameter, with a crest at the end with the micropyle. **Male cones** solitary, erect, narrowly ovoid, 30–50 cm (12–20 in) long, 8–10 cm (3.2–4 in) in diameter, pale fawn to pale orange-brown tomentose. Peduncle short, cone appearing sessile. Sporophylls 35–45 mm (1.4–1.8 in) long. Sporophyll face 20–25 mm (0.8–1 in) wide, sterile apex 7–10 mm (0.3–0.4 in) long, not curved backward and downward, its apical spine somewhat reduced, broad, sharply upturned, about 2 mm long. Sporangia in a single patch covering the entire underside of the sporophyll. **Habitat:** Forested country on coral limestone or coral sand, occasionally on volcanic soils on islands where such soils occur, at or near sea level. **Distribution:** Mariana Islands, reported from Guam (Merizo, lower slope of Mount Schroder, Ritidian Point) and Rota (north of Talofofo Bay and the track from Mackay Beach). Caroline Islands, Palau (east coast of Babelthuap Island and Purple Beach on Peleliu Island) and Yap (near Moloai).

For many years, *Cycas micronesica* was misidentified as either *C. circinalis* or *C. rumphii.* It can be distinguished from those two species by its larger seeds, probably the largest in the genus, and its predominantly unarmed petiole.

The Chamorro Indians of the Mariana Islands use *Cycas micronesica* as food. Flour is produced from the central pith of the stem or the endosperm of the seed. This substance is rich in starch but contains a poisonous constituent that can cause paralysis in humans and other animals. The Chamorro first learned how to process and detoxify the seed and stem of this cycad from the

Spanish around 1800. Processing the material consists of chopping up seeds or pith, soaking in water for 10 days, then drying and grinding into powder. From this flour, tortillas can be made. On Guam, the cycad is referred to as *federico* and is said to be widely cultivated.

In cultivation, *Cycas micronesica* is one of the fastest growing species in the genus, and under the right conditions it will form large specimens in a very few years. *Cycas micronesica* is best grown from seed, but seed may sometimes take 2 years to germinate. Once the seed germinates, growth is quite rapid. In temperate climates the growth rate is not as rapid and plants can suffer damage when exposed to frost. Given the proper climate, *C. micronesica* must be considered one of the better species to use in the landscape. It is undemanding in its requirements and generally pest-free. Occasionally, infestations of mealybugs may occur at the apex, especially when a female cone is being produced. Using a cholinesterase-inhibiting organophosphate insecticide such as Diazinon can easily control these. Usually two to three applications 7–10 days apart are required for complete control.

The conservation status of *Cycas micronesica* appears to be good. Since it is used as an item of food, it is not indiscriminately destroyed. Quite to the contrary, it is widely cultivated and highly esteemed. For the present it may be considered as not threatened.

Cycas multipinnata C. J. Chen & S. Y. Yang 1994a,b

PLATE 153

Epicycas multipinnata (C. J. Chen & S. Y. Yang) de Laubenfels in de Laubenfels & Adema 1998

Cycas multipinnata, the epithet derived from *multi-,* Latin for many, and *pinna,* the primary division of a compound leaf, referring to the dichotomously divided leaflets and bi- or tripinnately branched rachis, is called *duoqi suitie,* referring to the branched rachis, and *dujuetie,* meaning single-leaf cycas as this cycad seldom has more than one leaf. Stems generally subterranean, 20–40 cm (8–16 in) long, 10–25 cm (4–10 in) in diameter, and retaining leaf base scars. Cataphylls 4.5–6 cm (1.8–2.4 in) long, 3–3.5 cm (1.2–1.4 in) wide at the base, gradually acuminate toward the apex. Leaves usually solitary, rarely two or three, erect, slightly keeled, bi- or tripinnate, 2–4 m (6.6–13 ft) long, 1.5–1.8 m (4.9–5.9 ft) wide. Rachis consistently terminated by paired leaflets. Petiole 1.5–2.7 m (4.9–8.9 ft) long, 1.7–2 cm (0.7–0.8 in) in diameter, armed 90–100% of its length with spines 3–5 mm (to 0.2 in) long spaced 30–35 mm (1.2–1.4 in) apart. Secondary rachis divisions 20–60 cm (8–24 in) long, usually with six to eight secondary branches on each side of the primary rachis, these secondary divisions longest at midleaf and decreasing in length toward the apex and base of the leaf. Leaflets in 7–18 pairs, only on the secondary branches of the rachis, each with a petiolule 1.5–3 cm (0.6–1.2 in) long, median leaflets 7–18 cm (2.8–7.1 in) long, five to seven times dichotomous, each leaflet division 1–2.3 cm (0.4–0.9 in) wide, papery, abruptly acuminate at the apex, spaced 16–20 cm (6.3–7.9 in) apart, midrib prominent above, flat below, margin flat and straight or slightly undulate. Female cones closed type, 16–18 cm (6.3–7.1 in) in diameter. Sporophylls 10–12 cm (4–4.7 in) long, each with two to six ovules. Lamina ovate, 6–7 cm (2.4–2.7 in) long, 5–6 cm (2–2.4 in) wide, margin pectinate with 20–22 pairs of soft lateral spines 3–4 cm (1.2–1.6 in) long, 3–4 mm wide at the base. Sarcotesta yellow when ripe. Sclerotesta subglobose, about 3 cm (1.2 in) in diameter. Male cones solitary, erect, cylindrical, 25–40 cm (9.8–16 in) long, 6–8 cm (2.4–3.2 in) in diameter, cream to yellow. Peduncle about 3.5 cm (1.4 in) long and 2.5 cm (1 in) in diameter. Sporophylls 2.5–3 cm (1–1.2 in) long. Sporophyll face 1 cm (0.4 in) high, 2–2.5 cm (0.8–1 in) wide, apical spine rudimentary or absent, upright, with two to six small apical serrations. Sporangia in a single rounded patch. Habitat: Limestone areas on very steep slopes in semishaded monsoon forest at elevations of 1000–1200 m (3300–3900 ft). Distribution: China, eastern Yunnan province, along the catchment of the Red River, called the Yuan in China and the Hong in Vietnam, probably in Honghe, Jianshui, Mengla, and Mile counties.

It is truly remarkable that a cycad as striking as *Cycas multipinnata* could have gone undescribed until 1994. Although known for several decades from Yunnan province, China, the plants were regarded as *C. micholitzii* and no particular interest was expressed in their discovery. It appears that local commercial collectors gathered the plants from 1986 to 1988. They were sold as ornamentals and for use in local landscaping. Most died as a result of injuries inflicted during collection and poor growing conditions. In 1987, specimens were distributed to different botanical gardens and to at least one cycad collector. *Cycas multipinnata* was botanically described in November 1994 by C. J. Chen and S. Y. Yang.

The closest relative of *Cycas multipinnata* is *C. debaoensis,* which occurs in adjacent Guangxi autonomous region some 350 km (215 miles) to the east. *Cycas debaoensis* also has the distinctive bipinnate leaves, but much smaller than those of *C. multipinnata.*

Cycas multipinnata is doubtless insect pollinated as the single male cone that has thus far been found was said to have many small black beetles in it. These beetles are believed to be the same species involved in the pollination of other Chinese cycads.

The single leaves of *Cycas multipinnata* bear a strong resemblance to a stalk of bamboo. This mimicry, which is shared with *C. micholitzii,* makes plants difficult to see in their habitat, especially at a distance or when they are in dense growth. Seedlings of *C. multipinnata* produce simple leaves, making them difficult to distinguish from other species of *Cycas.* In this respect, too, it is similar to *C. micholitzii,* whose seedlings also have simple leaves. The distinctive bipinnate leaves of *C. multipinnata,* with their divided leaflets, are not produced until plants are 2–3 years old.

Cultivation of *Cycas multipinnata* does not appear to pose any major problems. Photographs of plants in collections show them to be in good condition and growing well. It would be safe to assume that this cycad would prefer a subtropical to tropical climate or greenhouse culture for best results. Plants at the Montgomery Botanical Center, Miami, Florida, have grown rapidly, developing into beautiful specimens.

A survey conducted in early 1994 disclosed that only about 20 individuals of *C. multipinnata* existed in cultivation in five different institutions and private collections. Little remains of the forest in Yunnan where *C. multipinnata* was originally collected. Some of the forest remnants that exist have been investigated and a few additional plants of *C. multipinnata* located. Substantial rewards have been offered to the local inhabitants for information leading to the discovery of additional populations of this cycad, without much success, indicating that *C. multipinnata* is nearing extinction in the wild. The conservation status of *Cycas multipinnata* thus appears to be dire. Judging by the plight of all known Chinese cycads, *C. multipinnata* must be considered as very endangered. Every effort should be made to preserve the remaining plants in cultivation with the hope of producing seed through artificial propagation. We can only hope that this beautiful and most remarkable cycad does not become extinct in its habitat.

Cycas nathorstii J. Schuster 1932

PLATE 154

Cycas nathorstii is named in honor of Alfred Gabriel Nathorst (1850–1921), Swedish paleobotanist and phytogeographer. **Stems** arborescent. Cataphylls narrowly triangular, soft, thinly tomentose or glabrous, 5 cm (2 in) long, persistent. **Leaves** numerous, semiglossy, 1.6–1.8 m (5.2–5.9 ft) long, flat. Petiole 45–55 cm (18–22 in) long, glabrous, armed 90–95% of its length. Leaflets in 70–85 pairs, linear lanceolate, falcate, gradually acuminate, narrowed and decurrent at the base, 23–26 cm (9.1–10 in) long, 9–12 mm (0.4–0.5 in) wide, the upper surface shiny dark green, lower surface paler, the midrib prominent above and below. **Female cones** open type. Sporophylls 15–30 cm (6–12 in) long, densely brown tomentose, each with 6–12 ovules. Lamina subtriangular lanceolate or subrhomboid lanceolate, elongate, 40–65 mm (1.6–2.6 in) long, 18–25 mm (0.7–1 in) wide, margin extremely undulate, serrate to the base with 20–40 short teeth 2–4 mm long and spreading laterally, apex with a spine 10–14 mm (0.4–0.6 in) long. Sarcotesta yellow. Sclerotesta ovoid, somewhat flattened, about 55 mm (2.2 in) long and 40 mm (1.6 in) in diameter, the surface indistinctly roughened, fibrous layer present, spongy endocarp absent. **Male cones** solitary, narrowly ovoid, densely orange tomentose. Sporophylls 3–4 cm (1.2–1.6 in) long. Sporophyll face deltoid, 15–22 mm (0.6–0.9 in) wide, abruptly curved backward and downward into a somewhat thickened hooklike, elegantly arched tip about 1 cm (0.4 in) long. **Habitat:** Upland forests, usually in drier areas. **Distribution:** Sri Lanka (Ceylon), northern side of the island.

Although Julius Schuster's 1932 treatment of cycads in *Das Pflanzenreich* has received considerable and well-deserved criticism, Kenneth D. Hill felt that Schuster's *C. nathorstii* is a legitimate species. It is the only described *Cycas* native to Sri Lanka, but Schuster was of the opinion that it might be a hybrid between *C. circinalis* and *C. rumphii.* Schuster also named a subspecies from Sri Lanka that he called *C. rumphii* subsp. *zeylanica,* which may prove to be a good species.

There are very few specimens of *Cycas nathorstii* in cultivation, and I have only seen several seedlings that I grew from seed in 1980. I no longer have these plants in cultivation so I am not familiar with a mature specimen, though I feel it would be similar to *C. rumphii* in many respects. During the few years I grew the seedlings, they were trouble-free and relatively fast growing.

I find no indication in the literature regarding the conservation status of *Cycas nathorstii.* I do know that it is grown quite commonly in cemeteries in Sri Lanka as a grave marker and that such plants produce viable seed. Because of land clearance in Sri Lanka for crops and urban development, we must consider *C. nathorstii* endangered until more complete information is available.

Cycas nongnoochiae K. D. Hill 1999b

PLATE 155

The epithet for *Cycas nongnoochiae* refers to the Nong Nooch Tropical Garden, Thailand, commemorating its support of cycad research in Southeast Asia. **Stems** arborescent, generally unbranched, in larger specimens 2–5 m (6.6–16 ft) tall. Cataphylls narrowly triangular, soft, thinly tomentose, articulated. **Leaves** usually 20–25, semiglossy, gray-green to blue, 0.8–1.4 m (2.6–4.6 ft) long, flat and not keeled, apex consistently terminated by a spine 4–21 mm (to 0.8 in) long, emergent leaves densely white tomentose, the tomentum loose and soon shed. Petiole 23–35 cm (9.1–14 in) long (20–30% of total leaf length), glabrous, armed with spines 10–50% of its length. Leaflets in 60–100 pairs, angled forward 65–75°, opposing leaflets set an angle of about 180° to each other and thus nearly in the same plane, dark glaucous green above, lighter green below, basal leaflets gradually reduced to spines, median leaflets simple, glabrous, 12–22 cm (4.7–8.7 in) long, 9–12 mm (0.4–0.5 in) wide, spaced 8–11 mm (0.3–0.4 in) apart, margins either flat or slightly revolute, the lower one decurrent for 4–7 mm (to 0.3 in). **Female cones** closed type. Sporophylls 16–19 cm (6.3–7.5 in) long, white to yellow tomentose, each usually with two to four glabrous ovules. Lamina nearly circular to ovate, 8.5–10 cm (3.3–4 in) long, 6–7 cm (2.4–2.8 in) wide, margin deeply pectinate, with 36–52 soft lateral spines 20–24 mm (0.8–0.9 in) long, 2 mm wide, apical spine distinct, 15–25 mm (0.6–1 in) long, about 4 mm wide at its base. Sarcotesta about 2 mm thick, yellow when ripe, sometimes slightly glaucous, fibrous layer present but weakly developed. Sclerotesta smooth, interior spongy layer absent. **Male cones** solitary, erect, narrowly ovoid, 15–22 cm (6–8.7 in) long, 7–9 cm (2.8–3.5 in) in diameter, green or pale yellow tomentose. Sporophylls 22–30 mm (0.9–1.2 in) long. Sporophyll face flat, 14–19 mm (0.6–0.7 in) wide, apical spine prominent, sharply upturned, 7–9 mm (0.3–0.4 in) long. Sporangia in a single patch. **Habitat:** Low limestone hills and bluffs in seasonally dry deciduous forest, sometimes in low scrub, generally subjected to fire in the dry season. **Distribution:** Thailand, Nakhon Sawan province, known only from near Tak Fa.

Cycas nongnoochiae was first recognized as distinct in 1994 and was described in 1999. Its distinguishing characteristics are tall, arborescent stems and dark, deeply fissured bark. The closest relatives of *C. nongnoochiae* are thought to be *C. siamensis* and *C. clivicola,* especially *C. clivicola* subsp. *lutea,* and its female and male cones are described as being midway between the two other species. Kenneth D. Hill suggested that it may have originated as a hybrid between the two species but is now stabilized and reproducing and is best regarded as a separate species.

I am aware of no one outside Thailand who has had experience with *Cycas nongnoochiae* in cultivation. There should be no difference between its requirements and those of other related species such as *C. siamensis.* It comes from a seasonally dry habitat, so it would no doubt be a good choice for drier gardens. This would be a fine cycad for tropical to subtropical climates. It is too soon to predict if *C. nongnoochiae* may be able to grow in temperate climates as well.

Cycas nongnoochiae is locally abundant but apparently quite restricted in its distribution. It has been reported as being under pressure from plant collectors and should be regarded as threatened.

Cycas ophiolitica K. D. Hill 1992

PLATE 156

Cycas ophiolitica, the epithet derived from *ophio-,* Greek and pertaining to snakes, and *lithos,* rock, referring to this cycad's growing on soils derived from serpentine rock, is called Marlborough blue. **Stems** arborescent, erect, to 2 m (6.6 ft) tall, rarely as tall as 4 m (13 ft), 14–20 cm (5.5–8 in) in diameter. **Leaves** numerous, straight or slightly arched, 1–1.4 m (3.3–4.6 ft) long, 25–31 cm (10–12 in) wide, flat to slightly keeled, emergent foliage densely gray tomentose. Petiole 18–35.9 cm (7.1–14.1 in) long, armed with spines 3–4 mm long in smaller plants, plants more than 1 m (3.3 ft) tall usually unarmed, petiole and rachis usually with a persistent light covering of gray to light brown tomentum. Leaflets in 85–110 pairs, angled forward 80–120°, somewhat shorter at the leaf apex but not reduced or greater in length toward the leaf base, the surface lightly glaucous, turning dark green with age, median leaflets stiff, linear, abruptly acuminate, 14–24 cm (5.5–9.4 in) long, 6–8 mm (0.2–0.3 in) wide, midrib not raised or only slightly above, prominent below, margin straight and slightly revolute. **Female cones** open type. Sporophylls 18–30 cm (7.1–12 in) long, brown tomentose, each with two to six ovules. Lamina narrowly triangular, 40–70 mm (1.6–2.8 in) long, 12–30 mm (0.5–1.2 in) wide, toothed, apical spine 8–20 mm (0.3–0.8 in) long. Sarcotesta yellowish when ripe, with a more or less glaucous coating. Sclerotesta ovoid to globose, 29–33 mm (1.1–1.3 in) long, 28–32 mm (1.1–1.3 in) in diameter, light tan, more or less smooth except for a few shallow fissures in the area of the attachment. **Male cones** solitary, long ovoid, about 17 cm (6.7 in) long and

8 cm (3.2 in) in diameter, the surface rust brown tomentose. Peduncle short, cone appearing sessile. Sporophylls 32–40 mm (1.3–1.6 in) long. Sporophyll face curved backward and downward, 10–15 mm (0.4–0.6 in) long, apical spine sharply upturned, 7–11 mm (0.3–0.4 in) long. Sporangia in a single patch on the underside of the sporophyll. **Habitat:** Coastal *Eucalyptus* woodland in association with *Macrozamia miquelii* and *Xanthorrhoea* at elevations of 154–231 m (500–760 ft), generally red clay soil over serpentine rock. Rainfall averages 1000–1500 mm (39–59 in) annually, falling mainly in summer. Temperatures average 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Australia, Queensland, the center of distribution just south of Marlborough but the overall range starting north of Marlborough, extending as far south as Rockhampton.

When *Cycas ophiolitica* was first reported by collectors in the mid-1980s it was given the name Marlborough blue because of its glaucous leaves. I was able to investigate it in its habitat in 1986 and noticed that plants differ from typical *C. media,* which is common along the coast. The most obvious difference in the field is the gray-blue color of the new leaves. This feature is not apparent in plants with leaves more than a year old as the waxy coating that gives the glaucous cast to the foliage weathers away, and they become dark green. Plants are not often seen with old leaves because of the annual fires that pass through. Almost immediately after these fires, new growth is initiated and the plants soon have their gray-blue leaves replaced. The cycads in areas protected from fire may not produce new foliage for several years, and these plants with their dark green leaves could be mistaken for *C. media.*

Cycas ophiolitica does not present any problems in cultivation. When given the well-drained soil all cycads prefer, and applications of fertilizer during the growing season, *C. ophiolitica* soon grows into a handsome plant. The growth rate is not exceptionally rapid in this species, but it makes up for that in its ease of horticulture. Cold tolerance is good, and several degrees of frost have not caused any noticeable damage to plants in my collection. *Cycas ophiolitica* does best in a sunny location, as do most cycads with glaucous foliage.

I consider *Cycas ophiolitica* threatened. Many plants have been killed or disfigured in attempts to remove them from land used for raising cattle. In 1990 I observed dozens of plants that had been dug out with a backhoe and stacked along the side of a road in preparation for loading and transport. This was done, no doubt, for the nursery or landscape trade, and all plants of any size had been removed from the area. Because *C. ophiolitica* is a handsome cycad well suited for landscaping, removal of plants from their habitat will no doubt continue to be a problem as long as it is cheaper and easier to remove large plants from the wild. Apparently none of the populations is in a protected area, and many of them are easily accessible. The best long-term conservation solution for *C. ophiolitica* would be cultivation from seed to supply demand for the plants. The yearly seed crops are usually destroyed in part, or in whole, by the annual fires, further complicating conservation. It is hoped that governmental protection will be granted to the habitats of *C. ophiolitica* and a conservation scheme developed before the situation becomes critical.

Cycas orientis K. D. Hill 1994

PLATE 157

The epithet for *Cycas orientis* is derived from *oriens,* Latin for east, referring to this cycad's occurrence in the eastern part of Arnhem Land, Queensland, Australia. **Stems** arborescent, erect, sometimes branched, generally to 4 m (13 ft) tall, rarely as tall as 7 m (23 ft), 8–14 cm (3.2–5.5 in) in diameter. Cataphylls densely orange tomentose, hard, pointed, 4–8 cm (1.6–3.2 in) long. **Leaves** numerous, medium green, 0.6–1.3 m (2–4.3 ft) long, generally flat, emergent leaves densely white tomentose. Petiole unusually long, 17–35 cm (6.7–14 in), rarely as much as 52 cm (20 in), glabrous. Leaflets in 65–90 pairs, glossy medium green, lighter below than above, glabrous, flat, spaced 5–10 mm (0.2–0.4 in) apart, median leaflets 6–16 cm (2.4–6.3 in) long, 5–7 mm (0.2–0.3 in) wide, midrib slightly to moderately raised above, prominent below, margin straight and flat, decurrent for 2–4 mm. **Female cones** open type. Sporophylls 14–24 cm (5.5–9.4 in) long, densely gray to orange tomentose, each with one to four ovules. Lamina narrowly triangular, regularly toothed, with 10–16 lateral spines 4–8 mm (to 0.3 in) long, apical spine 14–63 mm (0.6–2.5 in) long. Sarcotesta orange when ripe, slightly glaucous. Sclerotesta globular to subovoid, slightly flattened, 25–36 mm (1–1.4 in) long, 25–34 mm (1–1.3 in) in diameter. **Male cones** solitary, ovoid, 18–20 cm (7.1–8 in) long, 8–9 cm (3.2–3.5 in) in diameter, lightly orange tomentose. Peduncle short, cone appearing sessile. Sporophylls 20–23 mm (0.8–0.9 in) long. Sporophyll face 14–16 mm (0.6 in) wide, projecting about 6 mm (0.2 in), apical spine upturned, 8–10 mm (0.3–0.4 in) long. **Habitat:** Low-elevation savanna forests with *Eucalyptus* dominant, generally in white to yellow sands over laterites. **Distribution:** Australia, Northern Territory, widespread in eastern Arnhem Land.

Kenneth D. Hill described *Cycas orientis* in 1994 during his revision of the Northern Territory populations of the genus. It is distinguished by having medium green leaves with flat leaflets, long petioles, and the midrib more prominent below than above. It appears to be most closely related to *C. armstrongii,* which differs in having the midrib prominent on both sides of the leaflets, and a generally smaller stature with more slender stems and shorter leaves with shorter petioles. Intergradation of *C. orientis* with *C. arnhemica* has been observed where their ranges adjoin.

Cultivation of *Cycas orientis* should be similar to that of other tropical species of *Cycas.* Because of its tropical habitat, with monsoonal weather, it should be given good drainage and kept somewhat on the dry side during winter if possible.

The conservation status of *Cycas orientis* is good as the species is locally abundant over a widespread area and occurs in remote country. Although *C. orientis* does not occur within any protected areas, its abundance should protect it in the long term. Almost all populations of *C. orientis* occur on Aboriginal land, and conservation strategies have not been developed in these areas.

Cycas pachypoda K. D. Hill in Hill et al. 2002

PLATE 158

The epithet for *Cycas pachypoda* is derived from *pachys*, Greek for thick, and *podion*, foot, referring to the distinctively swollen base. **Stems** arborescent, erect, 0.5–3 m (1.6–9.8 ft) long, 12–17 cm (4.7–6.7 in) in diameter. Cataphylls narrowly triangular, soft, lightly tomentose to glabrous, articulated, 8–11 cm (3.2–4.3 in) long. **Leaves** generally 50–80, semiglossy, deep green to gray green, 0.9–1.3 m (3–4.3 ft) long, slightly keeled, emergent leaves densely white tomentose, soon becoming glabrous. Petiole glabrous, 10–20 cm (4–8 in) long, spiny 80–100% of its length. Leaflets in 80–125 pairs, much lighter below than above, apex acute but not spiny, median leaflets angled forward 50–60°, flat or slightly keeled, 12–18 cm (4.7–7 in) long, 6–8 mm (0.2–0.3 in) wide, spaced 6–12 mm (0.2–0.5 in) apart, decurrent for 3–5 mm (to 0.2 in), midrib raised above and below, margin flat or slightly revolute. **Female cones** closed type. Sporophylls 7–15 cm (2.8–6 in) long, densely brown tomentose, each with two to four glabrous ovules. Lamina broad lanceolate, 9–12 cm (3.6–4.7 in) long, 4–7 cm (1.6–2.8 in) wide, deeply pectinate, with 30–36 soft lateral spines 1–2 cm (0.4–0.8 in) long, 1–2 mm wide at the base, apical spine distinct, 1.5–4 cm (0.6–1.6 in) long, 4–5 mm (0.2 in) wide at its base. Sarcotesta yellow, fibrous layer absent. Sclerotesta flattened ovoid, smooth, spongy endocarp absent. **Male cones** solitary, narrowly ovoid, 25–40 cm (10–16 in) long, 10–15 cm (4–6 in) in diameter, orange or brown tomentose. Sporophylls 40–52 mm (1.6–2 in) long, 17–20 mm (0.7–0.8 in) wide. Sporophyll face 7–12 mm (0.3–0.5 in) long, apical spine prominent, sharply upturned, 9–15 mm (0.4–0.6 in) long. **Habitat:** Dry open shrublands on coastal hills covered with granite boulders, in soil derived from granite. **Distribution:** Vietnam, Bình Thuân province, southern coastal area.

Cycas pachypoda is closely related to *C. pectinata* but can be readily distinguished from that species by its somewhat keeled leaves with short petioles, smaller and narrower male cones with shorter apical spines on the microsporophylls, and the overall smaller megasporophylls. *Cycas pachypoda* is also closely related to *C. clivicola* and *C. condaoensis* and can be separated from them by its heavily spined petioles and larger male cones with longer microsporophylls.

Cycas pachypoda is an interesting cycad with its swollen base and relatively short, slightly keeled leaves. It would be the perfect choice for a dry garden in a tropical to subtropical climate. I am not aware, however, of this species being available outside Vietnam. We must hope that seeds or seedlings will be made available to growers in other countries.

The conservation status of *Cycas pachypoda* is apparently secure. It is locally abundant in its area of distribution in southern Vietnam and has not been reported to be under pressure from collectors or land clearance.

Cycas panzhihuaensis L. Zhou & S. Y. Yang in Zhou et al. 1981

PLATE 159

Cycas baguanheensis L. K. Fu & S. Z. Cheng in Zhou et al. 1981

The epithet for *Cycas panzhihuaensis* refers to Panzhihua, Sichuan province, China, a city located near the first discovered colony of this cycad. **Stems** arborescent, upright, suckering from the base, in older specimens 1–3 m (3.3–10 ft) tall, and 15–25 cm (6–10 in) in diameter. Cataphylls lanceolate, 40–60 mm (1.6–2.4 in) long, 8–15 mm (0.3–0.6 in) wide. **Leaves** numerous, spreading, 0.7–1.5 m (2.3–4.9 ft) long, flat. Petiole 14–20 cm (5.5–8 in) long, armed in the upper portion with 3–17 pairs of spines 1–3 mm long spaced 10–18 mm (0.4–0.7 in) apart. Leaflets in 70–105 pairs, linear to linear lanceolate, straight or slightly falcate, thick and leathery, apex acuminate, surface covered by a heavy waxy coating, looking glaucous green, midrib flat or slightly raised above, raised below, median leaflets 12–23 cm (4.7–9.1 in) long, 6–7 mm (0.2–0.3 in) wide, margin flat to somewhat revolute. **Female cones** closed type. Sporophylls 15–24 cm (6–9.4 in) long, densely yellow-brown or reddish brown tomentose, each with two to six ovules, coning March–May, seeds ripening August–September. Lamina broadly expanded into a rhomboid or ovate form, pinnatifid, 3.5–5.5 cm (1.4–2.2 in) wide, with 15–20 sharply pointed, spreading segments 1–4 cm (0.4–1.6 in) long, the spinelike segments glabrous when mature. Sarcotesta glabrous, glossy, orange-red when ripe, papery and easily split when dry. Sclerotesta almost globose, slightly compressed, 23–27 mm (0.9–1.1 in) long, 20–25 mm (0.8–1 in) in diameter, the surface nearly smooth and not angled. Chalaza with one to three pits. **Male cones** solitary, spindle shaped, cylindrical, or ellipsoid cylindrical, slightly to prominently crooked, 20–50 cm (8–20 in) long, 8–11 cm (3.2–4.3 in) in diameter, apex abruptly acuminate. Peduncle 4–6 cm (1.6–2.4 in) long. Sporophylls overlapping, deflexed, narrowly wedge shaped, 4.5–6 cm (1.8–2.4 in) long. Sporophyll face 22–28 mm (0.9–1.1 in) wide, apical spine erect, 3–5 mm (to 0.2 in) long, densely yellow-brown tomentose. Sporangia in a single patch. **Habitat:** Steeply sloping river valleys in sparsely tree-covered grassland at elevations of 1100–2000 m (3600–6600 ft), commonly associated with *Quercus, Rhus,* and many grasses, in brown soil that is poor but deep and derived from limestone and sand-shale. Rainfall averages 760 mm (30 in) annually, falling mostly in summer, June–October. The maximum high temperature is 40.7°C (105°F), the minimum −1.4°C (30°F). Frost occurs in winter, the first in early December, the last in mid-January. **Distribution:** China, Sichuan province, Dukou county, area of the Baguan and Jinsha Rivers, and Ninguan county; Yunnan province, Huaping and Yuanmou counties.

Until more recently, *Cycas panzhihuaensis* has been all but unknown outside China. This scarcity of material is because in the past, very little plant material was allowed to leave China. It is definitely not the result of a lack of seed as a report from the Horticulture Department of Dukou states that 1500 kg (3300 pounds) of seed was collected in 1982. Even in off years, 50–100 kg (110–220 pounds) of seed has been collected. Since the seed of *C. panzhihuaensis* is somewhat smaller than that of *C. revoluta,* such weights would work out to about 115 seeds per kilogram (52 per pound). Evidently, the Horticulture Department of Dukou plants this seed, a germination rate of about 80% has been stated as usual. What such a large quantity of seedlings was used for was not stated.

From the information at hand, it would appear that *Cycas panzhihuaensis* is easy to grow and develops rapidly. The species has a pleasing gray-green leaf, which would contrast well with *C. revoluta* in garden plantings. Considerable frost tolerance could be expected because of the cold winters in its habitat. If a dependable supply of seed could be made available outside China, *C. panzhihuaensis* would no doubt become very popular in the same areas where *C. revoluta* is grown.

The conservation status of *Cycas panzhihuaensis* does not seem to be very secure. Four colonies are known, two in Sichuan province, two in Yunnan province. The first and largest colony discovered was near Dukou, Sichuan. This colony has been well studied, and a count of the plants within it was said to be more than 120,000. The mountain on which these plants grow is the site of a large mining operation, however, which has reached the lower part of the colony. It has also been noted that in more recent years, many plants have been removed to be used as decoration. Taking all facts into consideration, *C. panzhihuaensis* must be considered threatened.

Cycas papuana F. Mueller 1876b

Cycas circinalis subsp. *papuana* (F. Mueller) J. Schuster 1932, *C. rumphii* f. *papuana* (F. Mueller) Kanehira 1938

The epithet for *Cycas papuana* refers to Papua New Guinea, where this cycad is native. **Stems** arborescent, erect, to 2.5 m (8.2 ft) tall, rarely as tall as 4 m (13 ft), 15–20 cm (6–8 in) in diameter. Cataphylls densely orange tomentose. **Leaves** numerous, flat to slightly keeled, apex frequently terminated by a spine, emergent leaves densely and loosely tomentose with white hairs and a few orange ones, soon becoming glabrous. Petiole usually glabrous, 30–40 cm (12–16 in) long, without spines. Leaflets in 90–120 pairs, glabrous, dull green or bluish green after emergence, becoming dull to semiglossy medium green at maturity, lighter below, angled forward 45–70°, opposing leaflets at an angle of 130–180° to each other and thus in the same plane or nearly so, the attachment narrowed to 3–6 mm (to 0.2 in), spaced 5–14 mm (0.2–0.6 in) apart, basal leaflets not gradually reduced to spines, median leaflets 8–17 cm (3.2–6.7 in) long, 5–9 mm (0.2–0.4 in) wide, midrib raised and more or less equally prominent above and below, margins flat, the lower one decurrent for 2–5 mm (to 0.2 in). Female cones open type. Sporophylls 16–20 cm (6.3–8 in) long, gray and orange tomentose, each with two to six ovules. Lamina triangular, 35–50 mm (1.4–2 in) long, 17–25 mm (0.7–1 in) wide, regularly toothed, with 14–20 lateral spines 2–4 mm long, apical spine 8–15 mm (0.3–0.6 in) long. Sarcotesta 1.5–2.5 mm thick, orange when ripe. Sclerotesta flattened ovoid, 32–35 mm (1.3–1.4 in) long, 25–28 mm (1–1.1 in) in diameter. Male cones solitary, erect, ovoid, 15–20 cm (6–8 in) long, 8–10 cm (3.2–4 in) in diameter, densely and finely orange tomentose. Sporophylls 24–30 mm (0.9–1.2 in) long, the fertile zone about 17 mm (0.7 in) long. Sporophyll face 1–2 cm (0.4–0.8 in) wide, projecting about 7 mm (0.3 in), curved somewhat backward and downward, apical spine rudimentary, sharply upturned, about 5 mm (0.2 in) long. Sporangia in a single patch. Habitat: Sporadic but widespread in flat savanna woodlands, sometimes locally abundant. Distribution: Papua New Guinea, western district from the floodplains of the Fly River and around Daru to the west, at least to the Bensbach River.

Although described in 1876, *Cycas papuana* has not become well known or understood. Its closest relatives are considered to be the Australian species *C. armstrongii,* which has shorter leaves and petioles, and fewer leaflets, and *C. conferta,* which has somewhat shorter leaves, more crowded leaflets, less extended sterile microsporophyll apex, and larger seeds.

Cycas papuana is uncommon in cultivation, therefore not much is known about its horticultural requirements. There is no reason to believe that it would be more difficult to grow than most of the other tropical species of the genus. In light of its tropical habitat, *C. papuana* would probably be frost sensitive, requiring protection in temperate climates. The conservation status of *C. papuana* appears to be quite secure because of its wide distribution and common occurrence.

Cycas pectinata Buchanan-Hamilton 1829

PLATE 160

Cycas circinalis var. *pectinata* (Buchanan-Hamilton) J. Schuster 1932

Cycas jenkinsiana W. Griffith 1854

Cycas pectinata, the epithet derived from *pectinatus,* Latin and meaning with narrow, closely set divisions like those of a comb, referring to the margins of the megasporophyll, is called *thakal* in Nepal, *thaljimura* in Assam, *diengsia-goda* in Khasi, and *mondaing* in Myanmar (Burma). Stems arborescent, erect, sometimes branched, 2–12 m (6.6–39 ft) tall, 14–20 cm (5.5–8 in) in diameter, rarely as much as 1 m (3.3 ft) in diameter, glabrous, yellowish, covered with scars of old leaf bases. Leaves usually 30–40, semiglossy, deep green to gray-green, curved slightly backward and downward, 1.5–2.4 m (5–7.9 ft) long, 34–48 cm (13–19 in) wide, flat, with a fine covering of deciduous hairs, especially the midrib. Petiole 30–80 cm (12–32 in) long and armed with spines 30–80% of its length. Leaflets angled forward 45–60°, much lighter below than above, slightly falcate, linear, tapering to a minute spine, basal leaflets not reduced to spines and 5–16 cm (2–6.3 in) long, median leaflets 18–31.5 cm (7.1–12 in) long, 7.5–10.5 mm (0.3–0.4 in) wide, midrib prominent above and below, margins entire and flat or curved slightly backward and downward, the lower one decurrent for 4–8 mm (to 0.3 in). Female cones closed type, about 45 cm (18 in) in diameter. Sporophylls 22–30 cm (8.7–12 in) long, densely gray to brown tomentose, each with two to four glabrous ovules just below the lamina. Lamina nearly circular, 11–18 cm (4.3–7.1 in) long, 10–13 cm (4–5.1 in) wide, margin deeply pectinate, with 40–50 soft lateral spines 26–75 mm (1–3 in) long, 2–3 mm wide, apical spine distinct, 35–75 mm (1.4–3 in) long, 5–12 mm (0.2–0.5 in) wide at its base. Sarcotesta yellow when ripe. Sclerotesta very irregularly ovoid with several flat sides from compression, 34–42 mm (1.3–1.7 in) long, 23–33 mm (0.9–1.3 in) in diameter, light tan, relatively smooth. Chalaza 7–12 mm (0.3–0.5 in) in diameter, projecting. Male cones solitary, erect, ovoid, 30–55 cm (12–22 in) long, 16–22 cm (6.3–8.7 in) in diameter, yellow to yellow-orange tomentose. Peduncle short, cone appearing sessile. Sporophylls 43–60 mm (1.7–2.4 in) long. Sporophyll face triangular, 19–24 mm (0.8–0.9 in) wide, apical spine well developed, erect, 17–32 mm (0.7–1.3 in) long. Habitat: Open plains and foothills, sometimes in medium to tall forest, in moderate to deep shade, in soils that are deep, rich in clay, and fertile, at elevations averaging 600 m (2000 ft). Distribution: India and Nepal, reported from the tropical regions of the eastern Himalayas, and Bangladesh, Myanmar (Burma), and Thailand.

Cycas pectinata was originally described by Francis Buchanan-Hamilton, a Scot stationed in India who worked as a surgeon in the Bengal medical service, 1795–1815. His interest in plants led to many collecting trips in Bengal and finally to his serving as superintendent of the Calcutta Botanic Garden, 1813–1815. For many years the binomial *C pectinata* was attributed to William Griffith because of his posthumous publications of 1854, in which *C. pectinata* was also described. It seems that Griffith's practice was to add his name to new binomials and to place no name on previously published ones.

It has been reported that the hill tribes of Assam, India, eat seeds of *Cycas pectinata,* and the emergent leaves are used as a vegetable. It has been written that the fleshy stem is pounded and used as a hair wash for diseased hair roots.

Numerous small collections and exportations of *Cycas pectinata* plants and seeds have been made over the years, mainly from India. In more recent times, seed of *C. pectinata* has been imported from Thailand. Some of these plants survive today in botanical gardens and private collections. Generally speaking, *C. pectinata* is not a common plant outside its native habitat. *Cycas pectinata* is easily grown outdoors in warmer climates and as a greenhouse plant. It also seems to do well in temperate climates if given some protection from frost. I am not aware of any special growing conditions necessary for the cultivation of this cycad.

The conservation status of *Cycas pectinata* seems to be quite secure. It is a widespread species, found in several countries and in difficult terrain. Although its habitat is continually being reduced, large populations remain and it is not under immediate threat.

Cycas petraea A. Lindstrom & K. D. Hill 2002

The epithet for *Cycas petraea* is derived from *petraeus,* Latin and meaning growing in rocky places, referring to this cycad's habitat of bare limestone cliffs and boulders. **Stems** arborescent, to 6 m (20 ft) long, 15–20 cm (6–8 in) in diameter. **Leaves** usually 50–100 in a crown, bright green, highly glossy, 1.4–2.3 m (4.6–7.5 ft) long, flat, emergent leaves densely white to orange tomentose, becoming glabrous at maturity. Petiole 25–40 cm (10–16 in) long, glabrous, unarmed or spiny to half its length. Rachis usually terminated by paired leaflets. Leaflets in 70–115 pairs, basal leaflets 10–12 cm (4–4.7 in) long, not reduced to spines, median leaflets lanceolate, much lighter below than above, 23–29 cm (9–11 in) long, 10–13 mm (0.4–0.5 in) wide, narrowed to 2–3 mm at the base, angled forward 50–70°, decurrent for 3–6 mm (to 0.2 in), spaced 13–17 mm (0.5–0.6 in) apart, flat, apex acute but not spiny, midrib raised above and below, margin flat. **Female cones** closed type. Sporophylls 18–22 cm (7.1–8.7 in) long, densely gray or brown tomentose, each with two to six glabrous ovules. Lamina round or ovate, 10–17 cm (4–6.7 in) long, 4.5–9 cm (1.8–3.5 in) wide, deeply pectinate, with 20–28 soft lateral spines 2–4 cm (0.8–1.6 in) long, 3–4 mm wide, apical spine distinct, 5.5–8.5 cm (2.2–3.3 in) long, 6–9 mm (0.2–0.4 in) wide at the base. Sarcotesta yellow, fibrous layer present. Sclerotesta flattened ovoid, smooth, spongy endocarp absent. **Male cones** solitary, ovoid or narrowly ovoid, orange or brown tomentose, 30–40 cm (12–16 in) long, 14–18 cm (5.5–7.1 in) in diameter. Sporophylls 4–5 cm (1.6–2 in) long. Sporophyll face 5–7 mm (0.2–0.3 in) high, 14–18 mm (0.6–0.7 in) wide, apical spine prominent, sharply upturned or gradually raised, 12–20 mm (0.5–0.8 in) long. **Habitat:** Open scrub with *Dracaena, Euphorbia,* bamboos, and numerous climbing vines on steep to precipitous limestone outcrops with no soil cover. **Distribution:** Thailand, northern central part of the country at Loei, Phu Kradung, and Ban Pong Khao, known only from a single line of limestone mountains flanking the Phu Kradung massif to the east.

Cycas petraea is one of the more recently discovered species of from Thailand. It occurs in a relatively remote area of northern central Thailand. Because of its smooth stem with a swollen base, its flat, glossy bright green leaflets, and its precipitous limestone habitat, this species resembles *C. clivicola. Cycas petraea* differs from *C. clivicola* in its overall larger size, with larger leaves and leaflets, and its male cones that are much larger, with longer sporophylls bearing longer apical spines.

Cycas petraea is not common in cultivation, probably the result of its remote and inaccessible habitat. This is a handsome cycad that would add to any landscape in tropical to subtropical climates. Because of its preference for growing on limestone cliffs and boulders, *C. petraea* will doubtless require a well-drained planting area.

The conservation status of *Cycas petraea* is very good. Although localized, *C. petraea* is an abundant species that occurs in relatively inaccessible sites. The habitat and population of *C. petraea* have been mostly untouched and there is no immediate threat to the survival of this species.

Cycas platyphylla K. D. Hill 1992

PLATE 161

The epithet for *Cycas platyphylla* is derived from *platys,* Greek for broad, and *phyllon,* leaf, referring to the broad lamina of the female sporophyll, not to the actual leaf. **Stems** arborescent, erect, rarely branched, to 2 m (6.6 ft) tall, rarely as tall as 4 m (13 ft), 17.5–22.5 cm (7–9 in) in diameter, the subterranean portion of the stem prominently swollen. Cataphylls slender, densely orange-brown tomentose. **Leaves** numerous, arching and bow shaped, glaucous to glossy green, 1–1.5 m (3.3–4.9 ft) long, 14–17 cm (5.5–7 in) wide, strongly keeled, with a persistent rust brown tomentum. Petiole 12–24 cm (4.7–9.4 in) long, spiny 60–100% of its length. Leaflets in 60–130 pairs, narrowly linear, glaucous, glabrous basal leaflets not reduced to spines, median leaflets angled forward 45–60°, 14–16 cm (5.5–6.3 in) long, 4–6 mm (0.2 in) wide, midrib flattened above, prominent below, margins strongly revolute, entire, ending in a pungent apex, the upper margin scarcely narrowed, the lower margin decurrent. **Female cones** open type. Sporophylls 16–32 cm (6.3–13 in) long, covered with a persistent light brown to tan tomentum, each with four to six ovules. Lamina ovoid lanceolate, 50–80 mm (2–3.2 in) long, 16–37 mm (0.6–1.5 in) wide, margin regularly and finely toothed, with 30–36 lateral spines 0.5–2 mm long, apical spine 20–25 mm (0.8–1 in) long. Sarcotesta glaucous orange-brown when ripe. Sclerotesta ovoid to subglobose, somewhat flattened, 32–40 mm (1.3–1.6 in) long, 25–28 mm (1–1.1 in) in diameter, light tan, the surface almost smooth. **Male cones** solitary, rarely two or three (?), erect, 15–20 cm (6–8 in) long, 8–11 cm (3.2–4.3 in) in diameter, densely rust brown tomentose. Peduncle short, cone appearing sessile. Sporophyll face 5–8 mm (0.2–0.3 in) high, 13–15 mm (0.5–0.6 in) wide, projecting 7–10 mm (0.3–0.4 in), apical spine erect, 6–9 mm (0.2–0.4 in) long. Sporangia in a single patch with a prominent apical notch. **Habitat:** Dry rocky terrain in open woodland consisting of *Eucalyptus, Grevillea,* and *Melaleuca* and surrounded by grasses, at elevations of 430–740 m (1400–2400 ft). Rainfall averages 1350 mm (53 in) annually, three-quarters of it falling during summer, December–April. Daytime temperatures range from 32°C (90°F) in summer to 7°C (45°F) in winter, with the lowest recorded –3°C (27°F). **Distribution:** Australia, central eastern Queensland, from Dimbulah in the north and east, Irvingbank to the south, and Chillagoe to the west.

When Kenneth D. Hill revised *Cycas* of Queensland, Australia, he discovered that the name *C. cairnsiana* had been misapplied to plants from the Petford district of the Atherton Tableland. He found that the type specimens of *C. cairnsiana* had been collected from a group of blue-leaved plants known as the Mount Surprise blue because of their proximity to the town of Mount Surprise, Queensland. With the name *C. cairnsiana* properly applied to the Mount Surprise population, it left the Petford plants as undescribed. To correct this omission, Hill described the Petford plants as *C. platyphylla* in 1992. The closest relatives of *C. platyphylla* would be *C. cairnsiana, C. couttsiana,* and *C. megacarpa,* all of which also have glaucous new foliage and strongly keeled leaves.

Strangely enough, *Cycas platyphylla* is not often seen in cultivation, even though it is common in its habitat. A handsome plant with its spreading blue-gray leaves, *C. platyphylla* is a fine garden subject and seems to make the transition from summer- to winter-rainfall areas without noticeable problems. This cycad prefers full sun and well-drained soil for best results. Although growth is somewhat slow from seed, plants make good progress if given sufficient fertilizer. The strong contractile roots of *C. platyphylla* pull the seedlings into the soil shortly after germination, and this can sometimes cause problems with crown rot when the potting soil is kept too wet. This cycad is hardy to several degrees of frost.

The conservation status of *Cycas platyphylla* is good. There are several large populations, all of which show liberal regeneration. The land is poor where these cycads grow, therefore no large-scale eradication attempts have been initiated. The only conservation problem in the foreseeable future might be overcollecting for landscape use.

Cycas pranburiensis S. L. Yang, W. Tang, K. D. Hill & Vatcharakorn 1999

The epithet for *Cycas pranburiensis* refers to the town of Pranburi, Thailand, where this cycad was discovered. **Stems** erect, frequently branched, 0.6–3 m (2–10 ft) tall, 8–10 cm (3.2–4 in) in diameter, base expanded to about 20 cm (8 in) in diameter, leaf bases only persistent near the apex, the remainder of the stem generally smooth and skinlike. Cataphylls narrowly triangular, soft, densely gray to yellowish brown tomentose, 25–80 mm (1–3.2 in) long, 9–12 mm (0.4–0.5 in) wide at the base. **Leaves** usually 15–25, glossy bright green above, pale green below, 0.5–1.2 m (1.6–3.9 ft) long, 27 cm (11 in) wide, slightly keeled. Petiole 8–25 cm (3.2–10 in) long, unarmed or nearly so with no spines or one pair just below the lowest leaflets. Leaflets in 15–53 pairs, leathery, glabrous, median leaflets 12–24 cm (4.7–9.4 in) long, 8–16 mm (0.3–0.6 in) wide, midrib obscure above, prominent below, margin straight and slightly revolute. **Female cones** open type. Sporophylls 10–24 cm (4–9.4 in) long, densely whitish yellow tomentose, each with two to four glabrous ovules. Lamina lanceolate, 22–90 mm (0.9–3.5 in) long, 12–27 mm (0.5–1.1 in) wide, margin toothed, with 12–24 indistinct lateral spines 2–3 mm long, apical spine distinct, 22–40 mm (0.9–1.6 in) long, 4–5 mm (0.2 in) wide. Sarcotesta yellowish orange when ripe, fibrous layer present. Sclerotesta flattened ovoid, 25–45 mm (1–1.8 in) long, 21–32 mm (0.8–1.3 in) in diameter. **Male cones** solitary, ovoid, erect, 9–28 cm (3.5–11 in) long, 5–10 cm

(2–3.9 in) in diameter, orange-yellow tomentose. Peduncle obscured by cataphylls, the cone appearing sessile. Sporophylls 3–7 cm (1.2–2.8 in) long. Sporophyll face 12–18 mm (0.5–0.7 in) wide, projecting 13–17 mm (0.5–0.7 in), apical spine upright, 2–5 cm (0.8–2 in) long. Sporangia in a single patch. **Habitat:** Low, jagged, limestone hills and cliffs rising above mangrove estuaries and dense thickets of vegetation at elevations of 5–30 m (16–100 ft), in full sun to partial shade and associated with *Dracaena, Euphorbia,* and *Ficus.* The climate is tropical and monsoonal with distinct wet and dry seasons. **Distribution:** Thailand, the northern peninsular part of the country, Phetchaburi province, restricted to the general area of the national park, Khao Sam Roi Yot, between Pran Buri and Kui Buri.

Cycas pranburiensis was discovered in 1926 but not recognized as distinctive and undescribed until botanical explorations in Thailand in 1995. This cycad is quite common but has a relatively restricted distribution. It grows at low elevations under coastal influence on limestone cliffs and hills, generally in full sun. The area where *C. pranburiensis* grows is known as Sam Roi Yot, which translates as 300 hills, referring to the numerous limestone promontories of the district.

In Thailand, *Cycas pranburiensis* is distinguished from all other species of the genus by its short leaves with broad, leathery leaflets and generally unarmed petioles, and the long, gently curving microsporophyll apex. It is distinguished from its two closest relatives, *C. litoralis* and *C. macrocarpa,* by its slender stem and small seeds.

To my knowledge, *Cycas pranburiensis* is only in cultivation at Nong Nooch Tropical Garden near Pattaya, Thailand. It has not been in cultivation long enough to comment on its growth habits, but I do not expect any difficulties in growing this cycad. Thus far, all species of Thai cycads have proven to be good garden subjects, and *C. pranburiensis* is not expected to be any different. Its slender stem and short leaves should make *C. pranburiensis* a fine ornamental for use in tropical to subtropical climates. It remains to be seen if it shows enough cold hardiness to be grown in temperate climates.

Although *Cycas pranburiensis* has a very restricted distribution, it occurs in great numbers and much of its habitat is in Khao Sam Roi Yot, a national park. Yet it has already suffered from the attention of local plant collectors, and numerous severed stems bear witness to this fact. For these reasons, *C. pranburiensis* must be considered threatened.

Cycas pruinosa Maconochie 1978

PLATE 162

The epithet for *Cycas pruinosa* is derived from *pruina,* Latin for a waxy surface, referring to the bluish pruinose or glaucous surface of the seed sarcotesta, not the leaves. **Stems** arborescent, erect, solitary or suckering from the base in old specimens and forming a clump, 2–3 m (6.6–10 ft) tall, 25–40 cm (10–16 in) in diameter. Cataphylls narrowly triangular, soft, to 7 cm (2.8 in) long. **Leaves** numerous, erect to spreading, straight or slightly arched, sometimes twisted toward the apex, gray-green or dark green, 0.9–1 m (3–3.3 ft) long, 16–36 cm (6.3–14 in) wide, strongly keeled. Petiole 8–23 cm (3.2–9.1 in) long, 11 mm (0.4 in) in diameter, armed 50–100% of its length. Rachis four-sided and flattened, glabrous. Leaflets in 65–160 pairs spaced 5–9 mm (0.2–0.4 in) apart, glabrous above and below, angled forward 40–60°, with a terminal spine about 2 mm long, stiff and brittle, basal leaflets gradually reduced to spines, median leaflets 11–17 cm (4.3–6.7 in) long, 2–4 mm wide, midrib raised above, prominently raised below, margin straight and strongly revolute, not decurrent. **Female cones** open type. Sporophylls pendent when seed ripe, 25–45 cm (10–18 in) long, rust brown tomentose, each with two to six ovules. Lamina lanceolate, 9.5–19 cm (3.7–7.5 in) long, 1.8–4 cm (0.7–1.6 in) wide, shallowly pectinate or regularly toothed, with 14–24 lateral spines 5–10 mm (0.2–0.4 in) long, 2–3 mm wide, apical spine 10–45 mm (0.4–1.8 in) long. Sarcotesta bluish except when glaucous waxy coating has been worn away, dark orange or brown when ripe. Sclerotesta globular ovoid, 31–38 mm (1.2–1.5 in) long, 28–30 mm (1.1–1.2 in) in diameter, tan, the surface indistinctly and irregularly ridged. **Male cones** solitary, spindle shaped, 35–45 cm (14–18 in) long, 5–7 cm (2–2.8 in) in diameter, densely orange-brown tomentose. Sporophylls deltoid, 2–3 cm (0.8–1.2 in) long. Sporophyll face 8–13 mm (0.3–0.5 in) wide, apical spine erect, 6–25 mm (0.2–1 in) long. Sporangia in a single patch. **Habitat:** Steep slopes and at the bases of granite cliffs at elevations of 30–60 m (100–200 ft), in association with *Brachychiton, Eucalyptus, Grevillea,* and *Spinifex.* **Distribution:** Australia, Western Australia, Kimberley region in the ranges west and south of the Kununurra and Ord River area, also in the Napier Range on Cycad Hill; Northern Territory, in the Spirit Hills on Bullo River station.

Cycas pruinosa was described in 1978 by John R. Maconochie, an Australian botanist who became interested in native cycads. Maconochie worked at the Northern Territory Herbarium, Alice Springs, near the habitat of two undescribed cycads, *C. pruinosa* and *C. calcicola,* which he described while working as Australian Botanical Liaison Officer at the Royal Botanic Gardens, Kew, England, in 1976–1977. Shortly thereafter, he lost his life while working in Africa and was not able to complete his research.

Cycas pruinosa exhibits an interesting color polymorphism of the foliage in some populations. The most common leaf color is blue-gray, seen in most plants in the Argyle, Kununurra, and Ord River populations. Plants from the Napier Range exhibit foliage that varies from blue to gray-green to dark green. Plants from the Deception Range populations are all green leaved. Through all these leaf colors, *C. pruinosa* populations maintain the pruinose—bluish—waxiness on the seed sarcotesta, from which the name of the species is taken.

In its habitat, the growth rate of *Cycas pruinosa* is slow because of the hot, dry weather conditions and poor, rocky soils in which it grows. It has adapted to this inhospitable environment in a number of ways. The contractile taproot of the seedling pulls the crown into the soil, thus protecting it from fire, predators, and the blazing sun. The leaves are protected with a bluish waxy bloom, which reflects heat and reduces water loss. And of course, as in many cycads, the old leaf bases insulate the aerial trunk against the annual fires.

Cycas pruinosa is uncommon in cultivation. An inhabitant of the tropical desert of the Northern Territory and Western Australia, it can at times be difficult to maintain under garden conditions. It is a dry growing and somewhat frost tender. *Cycas pruinosa* demands a well-drained soil mix with limited water during winter, and heat and water during summer. It grows readily from seed that sprouts easily. The first leaf is slow to make its appearance and will not do so until a large root system has developed. Once the first leaf is produced, the seedling settles into a slow but continual growth pattern in which individual leaves appear every few months.

The habitat of *Cycas pruinosa* covers a large geographical area, mainly in the Kimberley region in northern Western Australia, occurring as scattered colonies, often in rough, remote country, and this has helped protect it from poachers. Some of the colonies of *C. pruinosa* contain large numbers of individuals, and there is abundant reproduction. *Cycas pruinosa* is considered as not threatened.

Cycas revoluta Thunberg 1782

PLATES 8, 9, 19, 20, 29–31, 36, 163
Cycas revoluta var. *planifolia* Miquel 1842
Cycas revoluta var. *prolifera* von Siebold & Zuccarini 1846
Cycas revoluta var. *brevifrons* Miquel 1848
Cycas miquelii Warburg 1900, *Epicycas miquelii* (Warburg) de Laubenfels in de Laubenfels & Adema 1998
Cycas revoluta var. *robusta* Messeri 1927

Cycas revoluta, the epithet derived from *revolutus,* Latin for rolled back, referring to the margins of the leaflets, which are rolled under, is called sago palm, and *sotetsu* and *tosso* in Japan. **Stems** arborescent, often branched one or more times in older, generally male specimens, densely clothed with old leaf bases and cataphylls, blackish brown, usually 0.5–2 m (1.6–6.6 ft) tall but as tall as 8 m (26 ft) in extremely old specimens, 20–90 cm (8–36 in) in diameter. **Leaves** numerous, straight, stiff, dark green, upright, then spreading as cones or new leaves are formed, 0.6–1.5 m (2–4.9 ft) long, 16 cm (6.3 in) wide, slightly to strongly keeled. Petiole 5–7 cm (2–2.8 in) long, more or less four-sided, armed to its expanded base. Leaflets narrow, linear, angled forward about 45°, 9–18 cm (3.5–7.1 in) long, 5–6 mm (0.2 in) wide, with a terminal spine, midrib sunken above, raised below, margin entire, straight, and strongly revolute. **Female cones** closed type, solitary, densely covered by yellow-tan to orange-tan tomentum. Sporophylls 20–25 cm (8–10 in) long, densely tomentose, each with four to six ovules, tightly held to form a flattened dome-shaped head, the sporophyll stalk quadrangular, 10–15 cm (4–6 in) long, 1 cm (0.4 in) in diameter. Lamina somewhat ovate, 8–10 cm (3.2–4 in) long, 6–8 cm (2.4–3.2 in) wide, divided almost to the midrib with 12–18 linear, curved, spine-tipped segments. Sarcotesta orange to red-orange when ripe. Sclerotesta ovoid, slightly flattened, 3–4 cm (1.2–1.6 in) long, 2.5–3 cm (1–1.2 in) in diameter, light tan, the surface with a network of indistinct fissures and usually one or two longitudinal grooves along the outside edges. **Male cones** solitary, erect, conical to ovoid oblong, 40–60 cm (16–24 in) long, 7.5–10 cm (3–4 in) in diameter, densely yellow tomentose. Peduncle 2.5–3.5 cm (1–1.4 in) long, about 2 cm (0.8 in) in diameter, densely tomentose, the cone often appearing almost sessile. Sporophylls deflexed from the cone axis about 45°, 3.5–4 cm (1.4–1.6 in) long. Sporophyll face more or less deltoid, 8–10 mm (0.3–0.4 in) high, 10–15 mm (0.4–0.6 in) wide, including the erect apical spine that averages 5 mm (0.2 in) long. Sporangia in a single patch covering the entire undersurface except for a deep notch at the apex. **Habitat:** Usually in exposed locations on steep limestone cliffs and rocks overhanging the shoreline, sometimes in low dense forest in heavy shade, from sea level to about 300 m (980 ft). **Distribution:** Japan, from the southernmost part of Kyushu and throughout the Ryukyu Islands, also reported from China, Guangdong province, but probably from cultivated plants.

Cycas revoluta, commonly known as sago palm, is without doubt the most popular and widely used cycad. If a botanical garden has but one cycad in its collection, it will usually be *C. revoluta.* It is also used as a garden plant in every country that has a tropical to Mediterranean climate. *Cycas revoluta* is unexcelled as a landscape plant, and many hundreds of thousands are sold each year for this use. Its popularity is well deserved as it combines ease of cultivation, a usable size, beauty, freedom from most pests, and availability. Basically, only two insect pests must be dealt with when growing *C. revoluta,* scale insects (Plate 20) and mealybugs. When an infestation is present as new leaves emerge, a great deal of damage can be done. The developing leaves and leaflets become twisted and stunted, making the cycad very unsightly. For this reason it is a good idea to treat the plant with an insecticide just prior to the onset of new growth.

When both female and male plants are available, viable seed can be set quite easily. As the male cone starts its pollen release, it can be cut off and dusted over the female cone. Usually a good seed set can be accomplished in this manner. When seeds are ripe, usually indicated when sporophylls become dry and brittle, they can be removed and stored in a dry place about 4–5 months to allow the embryo to develop. After this time, they can be planted and should germinate within a month. Seedling growth is rapid if a balanced fertilizer is used occasionally.

Cycas revoluta is one of the few cycads that can be used in areas where ground salt or salt spray is a problem. In their native habitat, these cycads are often subjected to salt spray from waves breaking on the rocks and cliffs where they grow. For this reason, salt tolerance is very high.

Each year hundreds of thousands of seeds are collected from plants in habitat and exported. It was reported that 165,000 kg (182 tons) of seed was exported from the Ryukyu Islands in 1993. Thousands of plants are also exported annually for use in the nursery trade, 110,000 in 1993. The leaves of *C. revoluta* are collected, dried, and exported in great numbers for use as "palm" leaves on Palm Sunday. In more recent years, fresh leaves have become popular in the United States and Europe for use in floral arrangements. The export to the United States in a single year was reported to be 3,000,000 leaves. In Asia, the leaves have been used for many years as funeral decorations, and this association with death has made them unpopular for other decorative uses.

In Japan, especially the Ryukyu Islands, *Cycas revoluta* has had many economic uses. The economic importance of these plants to Japan was so great that in the eighteenth century their export was punishable by death. Use as food was not uncommon in the past, especially in times of famine. Both seeds and stems were used to produce a breadlike cake and soup. Fermenting the seeds produced an alcoholic drink, and emergent leaves were used as a vegetable. K. Nishida reported that 210,000 kg (230 tons) of *C. revoluta* seed was used each year for the production of laundry starch as early as 1934.

I have been told that crows and ravens play a major role in the dispersal of seeds of *Cycas revoluta.* They carry them to a perch on a cliff or small island where they eat the sarcotesta, then drop the seed, which falls onto the rocks below. It is said that *C. revoluta* is virtually the only plant on many of the small offshore rocks and islands. An aureate or golden variegated form occurs on the island of Kume in the Ryukyu Islands (Plate 9). A different, cultivated form called "variety *aurea*" has golden yellow leaflet tips.

Compared to most cycads, *Cycas revoluta* has a rapid growth rate. Cultivation in more tropical climates often produces two or more flushes of growth per year. A plant grown in Java was reported to have produced a stem 3 m (10 ft) tall in just 15 years. Growth is somewhat slower in more temperate climates, but even so, at least one growth flush is produced each year. Cold tolerance is well developed in *C. revoluta,* which has been reported to withstand temperatures as low as −6°C (21°F). It is interesting to note that the Chinese and Japanese have taken great pride in using *C. revoluta* as a subject for bonsai, the art of dwarfing trees to produce a specimen resembling a mature normal tree but much smaller in every dimension. Some bonsai specimens have been in the same families for hundreds of years and have great value.

The conservation status of *Cycas revoluta* is probably the most secure of any of the species of the genus. Over its range, *C. revoluta* is very abundant. It may be the least threatened of any species of cycad. This is surprising because of the length of time it has been used as an item of commerce. It is estimated that there are several hundred thousand plants in habitat. Regeneration is copious, and viable seed abundant.

Cycas riuminiana Porte ex Regel 1863

The epithet for *Cycas riuminiana* is named in honor of the 1863 president of the Moscow Garden Tree Society, a Mr. Riumin. Stems arborescent, erect, 0.4–5 m (1.3–16 ft) tall, 10–30 cm (4–12 in) in diameter. **Leaves** numerous, light green to somewhat glaucous, 1.2–2.4 m (3.9–7.9 ft) long. Petiole subterete, glabrous, usually armed with straight short spines from the base to the lower leaflets. Leaflets in 60 pairs or more, papery and flexible, narrowly linear lanceolate, straight or slightly falcate, tapering to a nonspiny apex, median leaflets 13–29 cm (5.1–11 in) long, 7–19 mm (0.3–0.7 in) wide, midrib more or less prominent, margin slightly revolute, flat or sometimes undulate. **Female cones** open type (?). Sporophylls densely red-brown tomentose, each with three to six ovules. Lamina rhomboid, about 4 cm (1.6 in) long and 3 cm (1.2 in) wide, margin minutely scalloped, finely toothed, ending in an awl-shaped tip 2–4 cm (0.8–1.6 in) long. Sarcotesta yellowish when ripe. Sclerotesta ovoid, 35–50 mm (1.4–2 in) long, 35–37 mm (1.4–1.5 in) in diameter, smooth. **Male cones** solitary, oblong cylindrical or long ovoid, 8–30 cm (3.2–12 in) long, 4–12 cm (1.6–4.7 in) in diameter, densely red-brown tomentose. Peduncle short, cone appearing sessile. Sporophylls 3–5 cm (1.2–2 in) long. Sporophyll face 10–18 mm (0.4–0.7 in) wide, apical spine upright, 5–18 mm (0.2–0.7 in) long, slender. Sporangia in two patches along the margins of the sporophyll. **Habitat:** Not described but probably low-elevation rain forest. **Distribution:** Philippines, coastal areas on the island of Luzon.

Cycas riuminiana was described in 1863, based on a sterile collection and so vaguely and incompletely as to be applicable to almost any species of *Cycas.* Eduard August von Regel noted,

> An outstanding new cycad, which Mr. Porte has imported from Manila, and the whole offering of which has been bought by the Moscow Garden Tree Society, which deal was made through Mr. [Ambroise] Verschaffelt recently. The cycad is closely related to *C. circinalis* and was named by Porte in honor of the president of the Moscow Garden Tree Society, Mr. Riumin, *C. riuminiana.* Although presently the genealogy of this new species is not known, there has been acknowledged a great enough difference to present this interesting, decorative species clearly as a new species.

It was not stated whether the *Cycas* was named before or after Riumin had purchased the entire collection. If one were suspicious, the thought might occur that Porte's choice of name was made to close, or at least enhance, the sale of plants to Riumin's organization.

In the years since it was named, *Cycas riuminiana* has been considered by several taxonomists to be synonymous with *C. rumphii,* but the *C. rumphii* to which it was referred was a plant native to Luzon in the Philippines. In my opinion, none of the various forms of *Cycas* in the Philippines is referable to *C. rumphii.* The type of *C. rumphii* is believed to be based on specimens from the Andaman Islands, located between the Bay of Bengal and the Andaman Sea. The Philippines contain a considerable number of *Cycas* habitats that have not been studied or that are known only through incomplete or sterile collections. Based on seed morphology alone, it would appear that the genus *Cycas* in the Philippines is quite varied. Seed samples include examples with and without the flotation pad common in most species of *Cycas* native to the South Pacific and Indian Ocean. Two species, one from Palawan (*C. curranii*), one from Culion (*C. wadei*), display a unique ridged sclerotesta unknown throughout the rest of the genus. For these reasons it is my feeling that *C. riuminiana* is indeed a distinct species.

The data I have used for describing *Cycas riuminiana* were taken from Julius Schuster's 1932 monograph of cycads. Schuster's data were used only because nothing else was available. Most of Schuster's determinations were based on a limited number of herbarium specimens and I cannot guarantee that the quoted measurements and descriptions refer exactly to *C. riuminiana.* There are no data available on the conservation status of *Cycas riuminiana.*

Cycas rumphii Miquel 1839

Cycas celebica Miquel 1839
Cycas rumphii var. *timorensis* Miquel 1840
?*Cycas corsoniana* G. Don 1842
?*Cycas recurvata* Blume ex J. Schuster 1932
?*Cycas rumphii* var. *subinclusa* J. Schuster 1932
?*Cycas sundaica* Miquel ex J. Schuster 1932

Cycas rumphii was named in honor of Georg Eberhard Rumpf or Rumphius (1627–1702), botanist, merchant, and physician. The synonymy is complex and there is uncertainty about some of the names, some of which were applied to plants cultivated in Europe in the nineteenth century. Possible synonyms are listed with question marks; see K. D. Hill (1994b) for more information. **Stems** arborescent, erect, sometimes branched, to 10 m (33 ft) tall, 11–25 cm (4.3–10 in) in diameter. Cataphylls linear, densely orange tomentose, 6–8 cm (2.4–3.2 in) long. **Leaves** numerous, spreading, 1.5–2.5 m (4.9–8.2 ft) long, flat, apex terminated by paired leaflets or a spine 1–3 mm long, emergent leaves densely and loosely tomentose with white and orange hairs, soon becoming glabrous. Petiole glabrous, 30–50 cm (12–20 in) long, armed with spines 30–100% of its length. Leaflets in 75–100 pairs, glabrous, dull green or bluish green when emergent, becoming glossy deep green at maturity, lighter below than above, base narrowed at the attachment to 4.5–7 mm (to 0.3 in), spaced 11–23 mm (0.4–0.9 in) apart, median leaflets angled forward 60–80°, flat, 20–28 cm (8–11 in) long, 12–16 mm (0.5–0.6 in) wide, midrib not sharply raised and more or less equally prominent above and below, margins curved slightly backward and downward, the lower one decurrent for 5–13 mm (0.2–0.5 in). FEMALE CONES open type. Sporophylls 18–35 cm (7.1–14 in) long, densely gray and orange tomentose, each with four to eight ovules. Lamina narrowly triangular, 5–7.5 cm (2–3 in) long, 3–4 cm (1.2–1.6 in) wide, not regularly toothed, with as many as 16 lateral spines to 4 mm long or bumps, apical spine 10–25 mm (0.4–1 in) long. Sarcotesta 3–4 mm thick, orange when ripe. Sclerotesta flattened ovoid, 45–58 mm (1.8–2.3 in) long, 35–45 mm (1.4–1.8 in) in diameter, smooth except for numerous shallow indistinct grooves, interior spongy layer present. MALE CONES solitary, erect, narrowly ovoid, 35–55 cm (14–22 in) long, 10–15 cm (4–6 in) in diameter, pale fawn to pale orange-brown tomentose. Sporophylls about 56 mm (2.2 in) long. Sporophyll face about 17 mm (0.7 in) high and 16 mm (0.6 in) wide, not curved backward and downward, apical spine somewhat reduced, sharply upturned, about 2 mm long, broad. HABITAT: Woodland or forest, mainly along coastal areas, at elevations usually less than 200 m (650 ft), generally in sandy soil over calcareous substrate. The climate is tropical, and the rain generally falls during summer. DISTRIBUTION: The range and taxonomy of *Cycas rumphii* are not well understood. The description here is made from collections from the type locality, namely, eastern Indonesia, including Irian Jaya, that is, western New Guinea. Its range may extend farther west, but specimens from western Indonesia and Malaysia appear to be different.

Cycas rumphii is distinguished by its broad, falcate, hard, and glossy leaflets with relatively broad bases, the long and almost entirely armed petiole, and the narrowly triangular megasporophyll lamina with its slender apical spine and reduced lateral spines. The name *C. rumphii* has been misapplied to numerous cycads in the South Pacific and Asia and it may take considerable time before the nomenclature of *Cycas* in this area can be stabilized. Without doubt, there are a number of undescribed species within this area that have yet to be recognized. The misapplication of the name *C. circinalis* to *C. rumphii* and its relatives has caused a great deal of confusion in the past. More recently, the clarification of these two species by Kenneth D. Hill has provided a better understanding of their differences, morphologically and taxonomically.

The seed of the *Cycas rumphii* complex is unique in that it has a pad of spongy material between the sclerotesta and the endosperm. This pad causes the seed to float and it is generally accepted that in past times this feature assisted in the distribution of these cycads. This may explain why the *C. rumphii* complex consists primarily of shoreline plants.

Cycas rumphii in cultivation is both a beautiful and useful plant. It has been used extensively as a landscape plant throughout the tropical and subtropical areas of the world, and there are few botanical gardens and conservatories that do not possess specimens. The hardiness of *Cycas* in general and *C. rumphii* in particular is remarkable, with occasional specimens growing well in warm temperate to temperate climates. In such cooler climates, hard frosts may defoliate *C. rumphii,* but recovery is usually rapid when the weather warms up. Its graceful palmlike appearance has made it a very popular landscape plant, used extensively wherever weather conditions permit.

The conservation status of *Cycas rumphii* appears to be secure. There have been inroads on its distribution by land clearance for agriculture or logging, but regeneration in habitat is good, and growth rapid.

Cycas schumanniana Lauterbach 1900

PLATES 164, 165

Cycas schumanniana is named in honor of Karl Moritz Schumann (1851–1904), curator of the Botanical Museum and a professor at the University of Berlin. STEMS arborescent, erect, usually unbranched, to 2 m (6.6 ft) tall, rarely as tall as 5 m (16 ft), 20–25 cm (8–10 in) in diameter. Cataphylls densely orange tomentose. LEAVES numerous, 0.8–1.5 m (2.6–4.9 ft) long, usually slightly keeled, frequently terminated by a spine to 3 mm long, emergent leaves densely and loosely tomentose with orange hairs, becoming glabrous at maturity. Petiole generally glabrous, 20–55 cm (8–22 in) long, usually armed with spines less than 50% of its length. Leaflets in 50–105 pairs, slightly to moderately keeled, spaced 7–18 mm (0.3–0.7 in) apart, glabrous, dull or bluish green when emergent, becoming glossy medium green at maturity, lighter below than above, basal leaflets not reduced to spines, median leaflets angled forward 45–70°, opposing leaflets at an angle of 130–160° to each other, sometimes as much as 180° to each other and thus in the same plane, 12–23 cm (4.7–9.1 in) long, 6–8.5 mm (0.2–0.3 in) wide, narrowed to 2–3.5 mm at the base, midrib flattened above, prominent below, margin slightly thickened and curved backward and downward, usually straight, decurrent for 3–6 mm (to 0.2 in). **Female cones** open type. Sporophylls 25–40 cm (10–16 in) long, gray and orange tomentose, each with two to six ovules. Lamina triangular, 3.5–10 cm (1.4–3.9 in) long, 2–5 cm (0.8–2 in) wide, regularly toothed, with 25–40 lateral spines 3–6 mm (to 0.2 in) long, apical spine 10–25 mm (0.4–1 in) long. Sarcotesta 3–4 mm thick, orange when ripe. Sclerotesta flattened ovoid, 32–39 mm (1.3–1.5 in) long, 25–30 mm (1–1.2 in) in diameter. **Male cones** solitary, ovoid, 18–30 cm (7.1–12 in) long, 8–12 cm (3.2–4.7 in) in diameter, densely orange tomentose. Sporophylls 3–4.5 cm (1.2–1.8 in) long. Sporophyll face 1.5–2 cm (0.6–0.8 in) wide, projecting 6–8 mm (0.2–0.3 in), not curved backward and downward, apical spine slender, sharply upturned, 7–15 mm (0.3–0.6 in) long. Sporangia in a single patch. **Habitat:** Locally abundant in savanna grasslands, less frequently in woodlands or forests with a dense grassy understory, from low to high elevations and recorded up to 1600 m (5200 ft) near Wau, Papua New Guinea. All of its habitats are generally burned annually. **Distribution:** Papua New Guinea, northern side of the island along the foothills of the Bismarck Range, predominantly in the valleys of the Markham and Ramu Rivers, extending south along the valley of the Bulolo River as far as Wau.

Carl Lauterbach described *Cycas schumanniana* in 1900 from material collected near the Bismarck Range on the island of New Guinea. The type specimen was held by the Museum of Natural History, Breslau (now Wrocław, Poland), and is presumed to have been destroyed during World War II. In the past, taxonomists generally placed *C. schumanniana* in synonymy under *C. circinalis* or *C. media.* In 1994, when Kenneth D. Hill was reviewing New Guinean *Cycas,* he reestablished it at the rank of species.

Cycas schumanniana is thought to be most closely related to the *C. media* complex. It does have affinities with *C. media,* both in its habitat and outward appearance. The closest relative of *C. schumanniana* is probably *C. campestris,* also from New Guinea. *Cycas schumanniana* may be distinguished from *C. campestris* by its longer leaves with longer, broader leaflets that are angled forward, and its larger seeds. The megasporophyll is longer and more robust, with the lamina somewhat narrower and with shorter lateral spines.

Based on species from similar habitats, the cultivation of *Cycas schumanniana* should not be difficult. The elevational range of this cycad would lead one to believe that it might survive in warm temperate climates without protection. *Cycas schumanniana* is in cultivation at the Montgomery Botanical Center, Miami, Florida, and a few private collections. I am not aware of any other cultivated specimens though I am confident there must be others.

The conservation status of *Cycas schumanniana* seems to be secure. The cycad is locally abundant in some areas and has an extensive distribution in areas not yet threatened by agriculture.

Cycas scratchleyana F. Mueller 1885a

PLATES 166, 167

Cycas circinalis var. *scratchleyana* (F. Mueller) J. Schuster 1932

Cycas scratchleyana is named in honor of Sir Peter Henry Scratchley (d. 1885), first governor of British New Guinea. **Stems** arborescent, erect, usually unbranched, to 8 m (26 ft) tall, rarely as tall as 12 m (39 ft), 10–25 cm (4–10 in) in diameter. Cataphylls linear, densely orange tomentose, 7–30 mm (2.8–12 in) long. **Leaves** numerous, 1.7–2.5 m (5.6–8.2 ft) long, flat, terminated by paired leaflets, emergent leaves densely and loosely white and orange tomentose, soon becoming glabrous. Petiole glabrous, 30–70 cm (12–28 in) long, armed with spines 80–100% of its length. Leaflets in 80–150 pairs, glabrous, dull green or slightly bluish green at emergence, becoming glossy medium green above and lighter below at maturity, apex drawn out, median leaflets angled forward 60–80°, 15–37 cm (6–15 in) long, 1–1.6 cm (0.4–0.6 in) wide, spaced 1–1.8 cm (0.4–0.7 in) apart, narrowed to 2.5–3.5 mm at the base, midrib often sharply raised, more or less equally prominent above and below, sometimes slightly more prominent below, margins slightly to distinctly curved backward and downward and frequently very strongly undulate, the lower one decurrent for 3–9 mm (to 0.4 in). **Female cones** open type. Sporophylls 20–40 cm (8–16 in) long, densely orange-brown tomentose, each with four to eight ovules. Lamina ovate, 4–7 cm (1.6–2.8 in) long, 3.5–5 cm (1.4–2 in) wide, regularly toothed, with 28–40 lateral spines 7–11 mm (0.3–0.4 in) long, apical spine 8–12 mm (0.3–0.5 in) long. Sarcotesta 3–4 mm thick, orange when ripe. Sclerotesta flattened ovoid, 43–50 mm (1.7–2 in) long, 32–35 mm (1.3–1.4 in) in diameter. **Male cones** solitary, narrowly ovoid, 35–55 cm

(14–22 in) long, 10–15 cm (4–6 in) in diameter, densely pale fawn to pale orange-brown tomentose. Peduncle short, cone appearing sessile. Sporophylls 3–5 cm (1.2–2 in) long. Sporophyll face 1.5–3 cm (0.6–1.2 in) wide, not curved backward and downward, apical spine sharply upturned, 2–4 mm long. Sporangia in a single patch. Habitat: Generally on ridges in moist forests, extending to similar forests on stabilized coral sand dunes and nearby headlands, particularly in the eastern part of its range, from near sea level to more than 900 m (3000 ft). Distribution: New Guinea, reported by Kenneth D. Hill as widespread in eastern New Guinea, extending from near-coastal sites to the foothills, from Milne Bay, Papua New Guinea, west to far southeastern Irian Jaya, Indonesia, mainly in the southern catchments.

Cycas scratchleyana was described by Ferdinand von Mueller in 1885 from material collected by William Edington Armit on the Argus Expedition into the area of Port Moresby, New Guinea, in 1883. The material sent to Mueller was scanty even by the standards of the time. It consisted of a few fragments of leaflets and several sporophylls from a male cone. Mueller stated that the leaflets were papery, not stiff, and shiny on both surfaces. The papery texture of the leaflets may have been the result of collecting immature leaves. The male sporophylls were said to be devoid of any prolongation or erect spine. It may have been these unusual sporophylls more than the texture of the leaflets that prompted Mueller to describe the specimen as a new species. Mueller was not new to cycads, and during his years of botanical study he described a total of 13 species. In 1993–1994 Kenneth D. Hill studied New Guinean *Cycas* in detail and delineated the true range and characteristics of *C. scratchleyana* and its close relatives. His research authenticated *C. scratchleyana* as a distinct species and provided up-to-date information on its morphology, range, and relationships.

To my knowledge, virtually no data are available regarding *Cycas scratchleyana* in cultivation. The only specimens I am familiar with are in the Marie Selby Botanical Gardens, Sarasota, and the private collection of Dr. U. A. Young, Tampa, Florida. These two specimens have grown rapidly from seed and developed into majestic cycads. They have exhibited marginal damage to leaflets after the rare freezes that sometimes occur in the area. Otherwise, their growth and health has been very good. The large size and undulate leaflet margins make *C. scratchleyana* a magnificent landscape plant. The conservation status of *Cycas scratchleyana* seems to be quite secure as it occurs commonly over a large range.

Cycas seemannii A. Braun 1876

PLATE 168

Cycas circinalis subsp. *seemannii* (A. Braun) J. Schuster 1932, *C. rumphii* f. *seemannii* (A. Braun) Kanehira 1938, *C. rumphii* var. *seemannii* (A. Braun) Parham 1948

Cycas seemannii, named in honor of Berthold Carl Seemann (1825–1871), botanist and botanical collector, trained at the Royal Botanic Gardens, Kew, who worked in Fiji and first collected material of *C. seemannii,* is called *longolongo,* mostly, in Fiji, and *langalanga, langolango, roro, tuawawa niu,* and *wiro.* Stems arborescent, erect, usually unbranched, 1–12 m (3.3–39 ft) tall, 10–30 cm (4–12 in) in diameter. Cataphylls narrowly triangular, densely orange tomentose, 5–9 cm (2–3.5 in) long, weakly pungent. Leaves as many as 50–80 in mature plants, dull bluish green when fresh, glossy medium green when mature, 1.4–2.3 m (4.6–7.5 ft) long, about 50 cm (20 in) wide, flat, terminated by paired leaflets or a spine 3–10 mm (to 0.4 in) long. Petiole terete, 25–50 cm (10–20 in) long, unarmed or rarely with a few short spines near the base, generally glabrous but somewhat tomentose at its swollen base. Leaflets in 70–115 pairs, linear lanceolate, spreading, falcate, gradually acuminate, glabrous, much lighter below than above, spaced 12–21 mm (0.5–0.8 in) apart, apex scarcely pungent, median leaflets angled forward 45–70°, flat, 19–32 cm (7.5–13 in) long, 8–15 mm (0.3–0.6 in) wide, margins distinctly revolute and sometimes slightly undulate, the lower margin decurrent for 4–10 mm (to 0.4 in). Female cones open type. Sporophylls 25–35 cm (10–14 in) long, gray and orange tomentose, each with three to eight ovules, the sporophyll stalk long. Lamina narrowly triangular, 5–10 cm (2–3.9 in) long, 2–4 cm (0.8–1.6 in) wide, regularly toothed, with 18–30 lateral spines 2–8 mm (to 0.3 in) long, apical spine distinct, 10–20 mm (0.4–0.8 in) long. Sarcotesta reddish brown to orange when ripe. Sclerotesta flattened ovoid with a wing-shaped crest at the apex, 45–60 mm (1.8–2.4 in) long, 36–48 mm (1.4–1.9 in) in diameter, light tan, the surface more or less smooth. Male cones solitary, erect, cylindrical to long ovoid, 35–55 cm (14–22 in) long, 10–15 cm (4–6 in) in diameter, light brown to orange-brown. Peduncle short, cone appearing sessile. Sporophylls 3–5 cm (1.2–2 in) long. Sporophyll face rhomboid, 1.5–3 cm (0.6–1.2 in) wide, projecting 4–6 mm (0.2 in), not curved backward and downward, apical spine sharply upturned, 2–8 mm (to 0.3 in) long, broad. Sporangia in a single patch. Habitat: Drier areas on rocky open slopes and ridges from sea level to 600 m (2000 ft). Rainfall is 1875 mm (74 in) annually. The minimum–maximum temperature range is 16–31°C (61–88°F). **Distribution:** Fiji Islands, recorded from Matuku, Ovalau, Vanua Levu, Vanua Mbalavu, Viti Levu, and the Yasawa Group but may occur on others. Kenneth D. Hill has stated that *Cycas seemannii* also occurs on Vanuatu (Efate), the Tonga Islands, and New Caledonia.

Cycas seemannii was first recorded during the voyage of H.M.S. *Herald,* led by Henry Kellett in 1845–1851. Berthold Seemann served as naturalist during the voyage and collected material in the Fiji Islands on Viti Levu and Ovalau that he assigned to *C. circinalis.* While studying this material a quarter of a century later, Alexander Carl Heinrich Braun noted differences between it and *C. circinalis,* leading to his description of *C. seemannii.*

When Seemann referred his collections from Fiji to *C. circinalis,* he included herbarium material from the Tonga Islands, which Joseph Banks and Daniel Carl Solander collected during James Cook's first voyage to the South Pacific in 1768. William Carruthers (1893) mentioned that the Tongan specimen "differs in the texture and form of the segments of the leaves, and the presence of a large terminal spine on the spadix." In his treatment of *Cycas* of the South Pacific, Kenneth D. Hill has seen fit to include the populations from Fiji, the Tonga Islands, New Caledonia, and Vanuatu under *C. seemannii.* I am not entirely comfortable with this grouping, though there is no question that all these populations are closely related. Future studies may indicate that there is more than one entity involved in these islands.

Cycas seemannii in the Fiji Islands has always been used as an item of food. The seeds are ground and made into *mandrai,* a type of bread. The fresh male cones are also said to be edible. Seemann stated that the starch-rich central pith of the trunk was reserved for the exclusive use of the chiefs. *Cycas seemannii* is frequently used in towns and villages as an ornamental.

Like most of the species of *Cycas* of the South Pacific, *Cycas seemannii* grows rapidly in cultivation. It is a handsome plant and well suited to landscape use. The lack of spines on the petiole make *C. seemannii* a good choice for gardens frequented by children and pets. This cycad is frost sensitive and should be grown in an area protected from cold winds. Occasional light frosts are not a problem, but extended periods of freezing temperatures will cause leaf burn or complete defoliation.

The conservation status of *Cycas seemannii* appears to be sound. Although a great deal of its habitat has been replaced by agriculture, *C. seemannii* is still frequently encountered in patches of undisturbed forest. Its range extends over several of the island groups, ensuring it from rapid eradication. The use of *C. seemannii* as an ornamental is widespread, and many of these landscape plants produce viable seed. *Cycas seemannii* may be considered vulnerable.

Cycas segmentifida D. Y. Wang & C. Y. Deng 1995

PLATES 169, 170

Cycas multifida H. T. Chang & Y. C. Zhong 1997
Cycas xilingensis H. T. Chang & Y. C. Zhong 1997
Cycas longiconifera H. T. Chang, Y. C. Zhong & Y. Y. Huang in Chang et al. 1998

The epithet for *Cycas segmentifida* is derived from *segmentatus,* Latin for segmented, referring to the finely dichotomous branching of the marginal spines of the megasporophyll lamina. **Stems** short arborescent, to 50 cm (20 in) tall and in diameter, the dry leaf remains persisting. Cataphylls deltoid lanceolate, 7–9 cm (2.8–3.5 in) long, 1.5–5 cm (0.6–2 in) wide. **Leaves** few, upright, 2.6–3.3 m (8.5–10.8 ft) long, 42–80 cm (16–32 in) wide. Petiole glaucous, 0.8–1.4 m (2.6–4.6 ft) long, armed with 33–55 pairs of straight spines to 4 mm (0.1 in) long. Leaflets in 55–96 pairs, dark glossy green above, pale green below, glabrous, median leaflets lanceolate, 21–40 cm (8.3–16 in) long, 11–17 mm (0.4–0.7 in) wide, midrib prominent above and below, margins flat and straight, the lower one only slightly decurrent. **Female cones** closed type. Sporophylls 11–22 cm (4.3–8.7 in) long, densely red-brown tomentose, each generally with four to six glabrous ovules, rarely two. Lamina ovate, 5–13 cm (2–5.1 in) long, 5–15 cm (2–5.9 in) wide, margin pectinate with 8–19 pairs of drawn-out, slender, pungent, often dichotomously divided lateral segments 1.5–7 cm (0.6–2.8 in) long, apical segment narrow and drawn out or rhomboid to lanceolate, 2–12.5 cm (0.8–4.9 in) long, 2–20 mm (to 0.8 in) wide, with one to four apical lobes. Sarcotesta yellow to yellow-brown when ripe. Sclerotesta globose, 28–35 mm (1.1–1.4 in) in diameter. **Male cones** solitary, erect, narrowly cylindrical, 30–60 cm (12–24 in) long, 5–12 cm (2–4.7 in) in diameter, yellow. Peduncle short, cone appearing sessile. Sporophylls wedge shaped, 1–2.5 cm (0.4–1 in) long, apical spine upturned, 2–3 mm long. Sporangia in a single patch. **Habitat:** Dense broadleaved forests at low elevations. **Distribution:** China, Guangdong province, Guangzhou and Shenzhen counties; Guangxi autonomous region, Nanning and Xilin counties; Guizhou province, Ceheng, Guiyang, Wangmo, and Xingyi counties; Yunnan province, Funing county.

Cycas segmentifida is a member of a small group of Asian *Cycas* species distinguished by their small stems and few, long, upright to arching leaves. *Cycas segmentifida* differs from *C. guizhouensis* by the larger size of the leaf, leaflets, and petiole, the glaucous petiole, and the dichotomous branching of the lateral segments of the megasporophylls. It differs from *C. balansae,* which has persistently tomentose petioles that are not glaucous and undulate leaflet margins. *Cycas simplicipinna* is also similar but has a green petiole rather than the glaucous petiole of *C. segmentifida.*

Few plants of *Cycas segmentifida* are known to be in cultivation. It has been reported to be growing in the Shenzhen Fairy Lake Botanical Garden and the South China Botanical Garden, Longyandong, both in Guangdong province, the Guizhou Botanical Garden, Guizhou province, and the Forestry Academy of Guangxi, Guangxi autonomous region. No mention has been made of difficulties in the cultivation of *C. segmentifida* nor are any expected. Judging by its habitat, it would prefer a tropical to subtropical climate and a shady growing area.

The conservation status of *Cycas segmentifida* is presumed to be secure. It has a wide distributional range compared to other Chinese species of the genus and for this reason is probably not threatened. In general, the Chinese do not like this group of cycads as landscape subjects or for growing in pots because of their small stems combined with long leaves. This low demand for cultivated plants will help in its conservation. But the present rate of deforestation throughout China places all native cycads in danger, therefore *C. segmentifida* must also be considered threatened.

Cycas semota K. D. Hill 1996

The epithet for *Cycas semota* is derived from *semotus,* Latin for remote or distant, referring to this cycad's occurrence in the northernmost extremity of the Cape York Peninsula, Queensland, Australia. **Stems** arborescent, erect, to 4 m (13 ft) tall, rarely as tall as 6 m (20 ft), 14–24 cm (5.5–9.4 in) in diameter. Cataphylls not pungent but the lower side finely gray-white tomentose, 4–7 cm (1.6–2.8 in) long. **Leaves** numerous, erect or spreading, 1.1–1.6 m (3.6–5.2 ft) long, 25–30 cm (10–12 in) wide, openly keeled, terminated by paired leaflets, emergent leaves loosely orange-brown tomentose. Petiole loosely orange-brown tomentose, 30–40 cm (12–16 in) long. Leaflets in 80–125 pairs, straight, glossy dark green, opposing leaflets at an angle of 100–130° to each other, producing a V-shaped cross section, glabrous or orange-brown tomentose, spaced 8–11 mm (0.3–0.4 in) apart, apex abruptly acuminate, median leaflets 14–20 cm (5.5–8 in) long, 6–8 mm (0.2–0.3 in) wide, midrib slightly raised above, prominent below, margins curved backward and downward, the lower one decurrent for 2–3 mm. **Female cones** open type. Sporophylls 13–20 cm (5.1–8 in) long, densely gray tomentose, each with two to eight ovules. Lamina lanceolate, 60–75 mm (2.4–3 in) long, 20–28 mm (0.8–1.1 in) wide, regularly or obscurely toothed, with 28–46 lateral teeth to 7 mm (to 0.3 in) long, 1–2 mm wide, apical spine 25–40 mm (1–1.6 in) long. Sarcotesta orange when ripe. Sclerotesta flattened ovoid, 30–35 mm (1.2–1.4 in) long, 26–30 mm (1–1.2 in) in diameter. **Male cones** erect, ovoid, 40–46 cm (16–18 in) long, 12–14 cm (4.7–5.5 in) in diameter, densely brown tomentose. Sporophylls 46–56 mm (1.8–2.2 in) long. Sporophyll face 12–16 mm (0.5–0.6 in) wide, apical spine upright, 8–10 mm (0.3–0.4 in) long. Sporangia in a single patch. **Habitat:** Grassy understory of moist *Eucalyptus* forest on shallow sandy soils over laterite. **Distribution:** Australia, Queensland, far northern Cape York Peninsula, locally abundant but restricted to the Bamaga district.

Kenneth D. Hill described *Cycas semota* in 1996. Although its existence had been known for a number of years before then, it had not been recognized as undescribed. I received seeds of what was to be *C. semota* in late 1980. They germinated well but did not thrive in the temperate Mediterranean climate of Los Angeles, California. The seedlings never grew well, and all died slowly over the next 4–5 years. Judging by their habitat, they would prefer tropical to subtropical climates and overhead cover for best growth and health.

The conservation status of *Cycas semota* is not secure. It is known to be locally abundant but very localized and is not protected in any way. All the known specimens are from a single population near the town of Bamaga, Queensland. Additional study is needed to establish the distributional limits of this species. Then, measures should be taken to protect the known population(s). It is apparently a rare species and should be considered potentially at risk.

Cycas sexseminifera F. N. Wei 1996

PLATE 171

Cycas longisporophylla F. N. Wei in Wei et al. 1997
Cycas spiniformis J. Y. Liang in Wei et al. 1997
Cycas acuminatissima H. T. Chang, Y. C. Zhong & Z. F. Lu in Chang et al. 1998

Cycas brevipinnata H. T. Chang, Y. Y. Huang & Y. C. Zhong in Chang et al. 1998

Cycas septemsperma H. T. Chang, Y. Y. Huang & H. X. Zheng in Chang et al. 1998

The epithet for *Cycas sexseminifera* is derived from *sex,* Latin for six, and *seminifer,* seed bearing, referring to the belief that the six seeds observed on the sporophyll of the type specimen was diagnostic. **Stems** subterranean or shortly arborescent, to 0.6 m (2 ft) long, 6–15 cm (2.4–6 in) in diameter. Cataphylls narrowly triangular, pungent or soft, lightly tomentose, 4–9 cm (1.6–3.5 in) long, persistent. **Leaves** usually 5–30, semiglossy deep green or gray-green, 0.5–1.1 m (1.6–3.6 ft) long, slightly keeled or flat, emergent leaves densely brown tomentose, shedding as the leaf matures. Petiole 12–40 cm (4.7–16 in) long, unarmed or spiny 5–80% of its length, glabrous. Leaflets in 30–65 pairs, median leaflets lanceolate, much lighter below than above, slightly keeled in section, 7–26 cm (2.8–10 in) long, 6–13 mm (0.2–0.5 in) wide, angled forward about 60–85°, decurrent for 2–5 mm (to 0.2 in), spaced 6–17 mm (0.2–0.7 in) apart, apex spiny, midrib slightly raised above and below, margins flat or revolute. **Female cones** closed type. Sporophylls 9–12 cm (3.5–4.7 in) long, densely brown tomentose, each with two to six glabrous ovules. Lamina round, 6–9 cm (2.4–3.5 in) long, 35–45 mm (1.4–1.8 in) wide, deeply pectinate, with 28–40 soft lateral spines 30–40 mm (1.2–1.6 in) long, 1.5–2.5 mm wide, apical spine distinct, 3–4 cm (1.2–1.6 in) long, 5–12 mm (0.2–0.5 in) wide at the base. Sarcotesta yellow, 1–2 mm thick, fibrous layer absent. Sclerotesta ovoid, 18–25 mm (0.7–1 in) long, 18–22 mm (0.7–0.9 in) in diameter, spongy endocarp absent. **Male cones** solitary, narrowly ovoid to spindle shaped, 12–26 cm (4.7–10 in) long, 5–7 cm (2–2.8 in) in diameter, orange tomentose. Sporophylls 2–3 cm (0.8–1.2 in) long. Sporophyll face 2–4 mm high, 1–2 cm (0.4–0.8 in) wide, apical spine rudimentary or absent, sharply upturned, to 3 mm long. **Habitat:** Crevices on bare limestone outcrops or vertical cliff faces with no visible soil. **Distribution:** China, widespread in southern and central Guangxi autonomous region. Vietnam, Cao Bang province adjacent to the Chinese border, and a disjunct occurrence in Thanh Hoa province south of Hanoi.

Cycas sexseminifera is a dwarf cycad with a small stem, short flat leaves, with short, narrow, flat, and rather stiff, pungent leaflets. The petioles are often unarmed but this is not a consistent characteristic. Because of its small size, *C. sexseminifera* is popular as both a pot and garden plant in China and Vietnam. This popularity has created a demand for this species in horticultural markets in both countries, which in turn has caused extensive collecting from the wild to meet the demand.

Although *Cycas sexseminifera* is grown extensively as a pot and garden plant in areas near its habitat, it is virtually unknown outside China and Vietnam. Judging from other species that are grown in Australia and the United States, *C. sexseminifera* should be a dependable and trouble-free garden plant in areas with tropical to warm temperate climates. The habitat of *C. sexseminifera,* limestone outcrops and cliffs, leads one to believe that good drainage is of prime importance to its proper cultivation. If sufficient numbers of *C. sexseminifera* ever became available outside China and Vietnam, I feel sure it could become a popular collector's item and garden plant.

The conservation status of *Cycas sexseminifera* is reasonably stable. Although the demand for wild-collected plants in both China and Vietnam continues, this species is extremely abundant in many inaccessible sites and therefore is not in any immediate danger.

Cycas siamensis Miquel 1863

PLATE 172

Epicycas siamensis (Miquel) de Laubenfels in de Laubenfels & Adema 1998

Cycas immersa Craib 1912

The epithet for *Cycas siamensis* refers to Siam, now Thailand, the country from which this cycad was described. **Stems** arborescent, erect, 1–1.5 m (3.3–4.9 ft) long but usually shorter, the subterranean portion swollen, and the persistent leaf bases packed with a dark red-brown tomentum, in older specimens the exterior barklike, cracking to form an intricate pattern. Cataphylls lanceolate, 2–3 cm (0.8–1.2 in) long, 1–1.5 cm (0.4–0.6 in) wide, the lower surface densely covered with red-brown tomentum. **Leaves** erect, then spreading, 78–97 cm (31–38 in) long, 16–22 cm (6.3–8.7 in) wide. Petiole 10–27 cm (4–11 in) long and armed with 5–12 pairs of spines 1–2 mm long. Rachis conspicuously angled above and below, more convex toward the apex, more or less glabrous. Leaflets in 86–107 pairs, linear lanceolate, straight or slightly falcate, with a pungent apex, median leaflets 8–11 cm (3.2–4.3 in) long, 5–7 mm (0.2–0.3 in) wide, upper surface glabrous, lower slightly brown tomentose, midrib sunken above and inconspicuous, strongly prominent below, margin flat to slightly revolute and entire. **Female cones** closed type. Sporophylls 6.5–12.5 cm (2.6–4.9 in) long, densely orange-brown tomentose, obovate except for the one or two ovules. Lamina 3–8 cm (1.2–3.2 in) long, 3–7 cm (1.2–2.8 in) wide, margin deeply divided with 18–22 pairs of lobes 5–15 mm (0.2–0.6 in) long, apical segment 15–30 mm (0.6–1.2 in) long, 3–6 mm (to 0.2 in) wide. Sarcotesta yellow to brownish yellow when ripe. Sclerotesta globose to ovoid, 27–29 mm (1.1 in) long, 22–30 mm (0.9–1.2 in) in diameter, tan, smooth. **Male cones** solitary, erect, oblong, 8–22 cm (3.2–8.7 in) long, 4–8.5 cm (1.6–3.3 in) in diameter, densely tan tomentose. Peduncle 1.4–5 cm (0.6–2 in) long, densely orange-tan tomentose. Sporophylls 1.5–2 cm (0.6–0.8 in) long. Sporophyll face 1–1.8 cm (0.4–0.7 in) wide, densely orange-tan tomentose, the upper part extending into an upward-directed spine 1–1.5 mm (0.4–0.6 in) long. **Habitat:** Seasonally dry deciduous monsoon forest with a warm, humid rainy season June–October, followed by a hot dry period November–February, at elevations generally less than 300 m (980 ft) in limestone-based soil among limestone boulders. **Distribution:** Thailand, northern half of the country, possibly extending into Myanmar (Burma), Laos, Cambodia, and Vietnam.

In 1862 Johannes Elias Teijsmann, while traveling in Siam (now Thailand), collected material of an unknown cycad in what is now Kanchanaburi province. His specimens were sent to Europe where Friedrich Anton Wilhelm Miquel, one of the leading cycad taxonomists of the era, described it the following year as *Cycas siamensis,* for more than half a century the only known species of the genus from Thailand. In 1912 William Grant Craib described *C. immersa* based on material collected by Arthur Francis George Kerr in northern Thailand between Phrae and Lampang, but *C. immersa* was subsequently placed in synonymy under *C. siamensis* by Julius Schuster (1932) and Tem Smitinand (1971). Increased interest in *Cycas* in the 1990s led to the discovery and description of several species in Thailand. The efforts of Kampon Tansacha, a Thai businessman and student of cycads, brought about the investigations in Thailand. Through his efforts and assistance, Kenneth D. Hill of the National Herbarium of New South Wales, Australia, undertook a revision of *Cycas* of Thailand. This entailed a great deal of fieldwork, ultimately leading to a better understanding of the Thai cycads and their relationships.

In cultivation, *Cycas siamensis* has proved to be difficult to grow. When grown in pots or in the ground, it requires excellent drainage. Too much moisture during its dormant season can cause a killing rot to develop. It is naturally deciduous and its leaves die annually, at which time it appears dead. It can take several weeks or even months until a new set of leaves emerges to take the place of the old ones. Under garden conditions this deciduous habit persists and does not change as it does with some of the other deciduous cycads. *Cycas siamensis* does not transplant easily, and there is a high mortality rate when it is transplanted from the wild. When *C. siamensis* is in good condition and holding a full flush of leaves, it is a handsome plant. These periods of peak condition are all too short, and I cannot recommend *C. siamensis* as a good garden plant.

The conservation status of *Cycas siamensis* is not healthy. Although once widespread and probably numbering in the millions, *C. siamensis* has been drastically reduced, its habitat converted to farmland. In some areas, *C. siamensis* may be locally abundant, but the destruction of the habitat of this species goes on. There are a few areas set aside as preserves that still hold populations of *C. siamensis,* and other locations where the ground is too rocky for agriculture, but these habitats remain under pressure from plant collectors. For these reasons, *C. siamensis* must be considered threatened.

Cycas silvestris K. D. Hill 1992

PLATE 173

The epithet for *Cycas silvestris* is Latin, meaning of the forests, referring to this cycad's habitat. **Stems** arborescent, to about 3 m (10 ft) tall, rarely as tall as 4–7 m (13–23 ft), 10–15 cm (4–6 in) in diameter. Cataphylls linear, pungent, about 13 cm (5.1 in) long. **Leaves** numerous, very glossy, bright to medium green, 1–2 m (3.3–6.6 ft) long, 30–60 cm (12–24 in) wide at midleaf, flat, emergent leaves densely gray-white to orange-brown tomentose, this condition usually persistent on the leaflets for some time. Petiole subterete, glabrous, 40–50 cm (16–20 in) long, armed with spines 10–90% of its length. Leaflets in 45–100 pairs, glabrous, glossy medium green, slightly falcate, median leaflets 15–30 cm (6–12 in) long, 9–15 mm (0.4–0.6 in) wide, spaced 12–14 mm (0.5–0.6 in) apart, narrowed to 4–5 mm (0.2 in) at the base, the midrib not raised or only slightly above, prominent below, margins curved slightly backward and downward, the lower one decurrent for 5–9 mm (0.2–0.4 in). **Female cones** open type. Sporophylls 25–30 cm (10–12 in) long, densely brown tomentose, each with 2–10 ovules. Lamina narrowly triangular to lanceolate, 3–8.5 cm (1.2–3.3 in) long, 1.5–4.5 cm (0.6–1.8 in) wide, regularly toothed, apical spine 8–15 mm (0.3–0.6 in) long. Sarcotesta yellowish when ripe. Sclerotesta ovoid to globose, 30–39 mm (1.2–1.5 in) long, 25–32 mm (1–1.3 in) in diameter. **Male cones** solitary, erect, 11–13 cm (4.4–5.2 in) long, 5 cm (2 in) in diameter. Peduncle short, cone appearing sessile. Sporophylls 20–22 mm (0.8–0.9 in) long. Sporophyll face 11–13 mm (0.4–0.5 in) wide, apical spine upright, 4–5 mm (0.2 in) long. **Habitat:** Coastal rain forest at low elevations in white sand. Rainfall is about 2000 mm (79 in) annually, falling mainly in summer. The temperature range is 20–30°C (68–86°F) summer and winter. **Distribution:** Australia, Queensland, northeastern tip of the Cape York Peninsula, the known colonies located both north and south of the Olive River estuary.

Cycas silvestris is native to the northeastern tip of the Cape York Peninsula, a very tropical and remote section of Queensland that has not been well studied, mainly because of its difficulty to access. Roads are poor or nonexistent in many parts of the Cape York Peninsula, and this and the great distances involved have hampered thorough exploration of the region. It is not surprising, then, that *C. silvestris* was not brought to the attention of the botanical community until 1974. In the early 1990s, renewed interest in the cycads in general resulted in study of Queensland *Cycas.* This study, mainly by Kenneth D. Hill, resulted in the description of six new species from Queensland, one of which was *C. silvestris.*

I have not seen specimens of *Cycas silvestris* nor do I know anyone who has them in cultivation. Hill differentiated this species from the rest of the Australian taxa by its broad leaflets, which he likened to those of *C. circinalis. Cycas silvestris* can be expected to have a reasonably fast growth rate, like that of other tropical species of the genus. All species of *Cycas* that I have grown have displayed a high degree of cold tolerance, even those from tropical areas such as Vanuatu and the Philippines. Thus we may expect *C. silvestris* to have a similar cold tolerance. Cultivation requirements should not be expected to differ from those of the better known tropical species such as *C. seemannii* or *C. thouarsii. Cycas silvestris* grows on stabilized sand dunes, generally under cover of rain forest. From this, we may reasonably presume that *C. silvestris* will prefer a constantly damp growing medium with good drainage and some overhead cover. Paul I. Forster of the Queensland Herbarium, Brisbane, stated that *C. silvestris* does not display the marked deciduous periods common to several of the Australian species of the genus. This evergreen condition would make this cycad a fine landscape plant. It is hoped that prudent seed collection of *C. silvestris* will allow it to become well established in cultivation without harming the natural populations.

Cycas silvestris is considered as not threatened because of its remote habitat. On the other hand, the known stands of *C. silvestris* are limited in number of individuals, and the area in which they occur is not conserved in any way. Because of these factors, it must be kept in mind that its status could change very rapidly.

Cycas simplicipinna (Smitinand) K. D. Hill 1995

PLATE 174

Cycas micholitzii var. *simplicipinna* Smitinand 1971

Cycas simplicipinna, the epithet derived from *simplici-,* Latin for simple, and *pinna,* the primary division of a compound leaf, thus simple leaflet and contrasting the leaflets of this cycad to the divided leaflets of *C. micholitzii,* is called *maphrao tao, phrao tao,* and *plong* in Thailand. **Stems** subterranean or in rare cases as much as 20 cm (8 in) above ground, and to 10 cm (4 in) in diameter. Cataphylls soft, about 4 cm (1.6 in) long. **Leaves** usually two to five, upright, then spreading, very glossy, dark green above, lighter below, 0.9–2.5 m (3–8.2 ft) long, 40–44 cm (16–17 in) wide, flat. Petiole 0.4–1.4 m (1.3–4.6 ft) long and armed with alternating short spines 60–100% of its length. Leaflets in 18–36 pairs, thin textured, linear, abruptly acuminate toward the pointed apex, basal leaflets not reduced to spines, median leaflets 20–56 cm (8–22 in) long, 1.4–2 cm (0.6–0.8 in) wide, spaced 3–4 cm (1.2–1.6 in) apart, midrib prominent above, flat below, margins flat to undulate, the lower margin decurrent for 5–10 mm (0.2–0.4 in). **Female cones** closed type. Sporophylls 8–12 cm (3.2–4.7 in) long, each generally with two ovules. Lamina rhomboid to ovate, 45–55 mm (1.6–2.2 in) long, 18–35 mm (0.7–1.4 in) wide, densely rusty tomentose, margin deeply pectinate, lacerate, with 10–14 soft lateral spines 1.5–2 cm (0.6–0.8 in) long, 1.5–2 mm wide, apical spine not distinct, 1.5–2 cm (0.6–0.8 in) long, 2–4 mm wide. Sarcotesta yellow when ripe. Sclerotesta flattened ovoid, 25–27 mm (1–1.1 in) long, 18–21 mm (0.7–0.8 in) in diameter, covered by a network of shallow grooves. **Male cones** solitary, subcylindrical, 15–21 cm (6–8.3 in) long, 2.2–4 cm (0.9–1.6 in) in diameter, narrowing toward both ends. Peduncle about 3 cm (1.2 in) long and 12 mm (0.5 in) in diameter, rusty tomentose. Sporophylls 12–14 mm (0.5–0.6 in) long. Sporophyll face 7–10 mm (0.3–0.4 in) wide, apical spine almost lacking. Sporangia in a single patch. **Habitat:** Tall evergreen tropical forest in deep shade, often along streams and in clumps of bamboo, at elevations of 600–1300 m (2000–4300 ft). **Distribution:** Thailand, northern sector near Chiang Mai (type locality) and Phrae; northeastern sector near Loci and Phetchabun. China, Yunnan province. Also reported as occurring in Myanmar (Burma), Vietnam, and Laos.

In 1958 and 1960 a Thai botanist, Tem Smitinand, collected specimens of a small cycad in Chiang Mai province in northern Thailand. He believed that the plants were a small form of *Cycas micholitzii* without the divided leaflets. When the *Flora of Thailand* was published, beginning in 1970, Smitinand published *C. micholitzii* var. *simplicipinna,* based on his original collections. In the early 1990s, Kenneth D. Hill of the Royal Botanic Gardens, Sydney, Australia, carried out a study of Thai *Cycas.* He determined that Smitinand's cycad, though belonging to the *C. micholitzii* complex, was worthy of recognition at the rank of species, and published the new combination *C. simplicipinna* in 1995. There is still some doubt that the Chinese plants identified as *C. simplicipinna* are the same species as those from Thailand because of differences in the shape of the megasporophyll lamina, number of ovules (two in the Thai plants, six in the Chinese), texture of the leaflets, and shape of the stem.

Cycas simplicipinna is not common in cultivation outside its native countries. Its leaves and leaflets are quite decorative, and its smaller size makes it useful where large-stemmed cycads would not fit into the landscape. It grows well in tropical and subtropical areas but has not proved to be very cold tolerant, so protection should be provided in temperate climates. As with most dwarf cycads, its growth rate is relatively slow. In the proper climate it cones freely and has been hybridized on at least one occasion with *C. revoluta.* Seedlings grown under proper conditions produce leaf growth that is relatively rapid, each new leaf about twice the length of the previous one until reaching their ultimate size. Contractile roots tend to pull the stem into the growing medium, so the only way its size can be ascertained is by exposing the plant.

The conservation status of *Cycas simplicipinna* is good. It is a very widespread species though never occurring in large or dense populations. Continued land clearance throughout Thailand and elsewhere is reducing the habitat and populations of *C. simplicipinna,* but many remain and the species can be considered not threatened.

Cycas sphaerica Roxburgh 1832

Cycas circinalis var. *orixensis* Haines 1924

The epithet of *Cycas sphaerica* is Latin for spherical, referring to the rounded seeds. **Stems** arborescent, to 4.5 m (14.8 ft) long, 25–40 cm (10–16 in) in diameter. Cataphylls narrowly triangular, soft, almost glabrous, persistent. **Leaves** semiglossy bright green, 1.5–2.7 m (4.9–8.9 ft) long, 40–60 cm (16–24 in) wide, flat. Petiole 45–60 cm (18–24 in) long, glabrous, armed 90% of its length. Leaflets lanceolate, flat, green above, lighter below, 19–32 cm (7.5–12.6 in) long, 9–12 mm (0.4–0.5 in) wide, midribs raised above and flat below, margin flat. **Female cones** open type. Sporophylls 15–25 cm (6–10 in) long, brown tomentose, each with 3–5 (K. D. Hill) or 3–12 (de Laubenfels) glabrous ovules. Lamina lanceolate, 38–55 mm (1.5–2.2 in) long, 20–30 mm (0.8–1.2 in) wide, regularly toothed, pungent, lateral spines 5–10 mm (0.2–0.4 in) long, apical spine distinct, 17–25 mm (0.7–1 in) long. Sarcotesta yellow to orange. Sclerotesta more or less spherical, 2.5–3 cm (1–1.2 in) long and wide, smooth. **Male cones** erect, narrowly ovoid, about 45 cm (18 in) long and 10 cm (4 in) in diameter, orange. Sporophylls 32–38 mm (1.3–1.5 in) long. Sporophyll face 15–22 mm (0.6–0.9 in) wide, apical spine 2–4.5 cm (0.8–1.8 in) long, narrow. **Habitat:** Dry forest and woodlands, generally on the sides and tops of hills. **Distribution:** India, northeastern peninsular part of the country in Orissa state.

William Roxburgh (1751–1815) described *Cycas sphaerica* in the posthumously published *Flora Indica.* It was placed in synonymy under *C. circinalis* by Friedrich Anton Wilhelm Miquel, then elevated once again to specific rank by David de Laubenfels in 1998. In 1924 Henry Haselfoot Haines described *C. circinalis* var. *orixensis* from specimens collected in Orissa, India. De Laubenfels has since placed this variety in synonymy under *C. sphaerica.* Haines claimed that variety *orixensis* had apical spines on the male sporophylls that were either divided into two lobes by a median cleft or divided into three lobes by two deep clefts. This abnormality has not been reconfirmed. Judging by the discrepancies in the measurements and descriptions of the various specimens now considered to be *C. sphaerica,* it would seem that additional collection and field research is necessary.

I am not aware of any cultivation information on *Cycas sphaerica*. No doubt it will be as easily grown as any of the *C. rumphii* complex. It should require tropical to subtropical climates, partial shade, and well-drained soil. The conservation status of *Cycas sphaerica* is not known.

Cycas taitungensis C. F. Shen, K. D. Hill, C. H. Tsou & C. J. Chen 1994

PLATE 175

The epithet for *Cycas taitungensis* refers to Ta'i-tung county, southeastern Taiwan, where the two known populations of this cycad are located. **Stems** arborescent, erect or decumbent, sometimes branched, suckering from the base, 1–5 m (3.3–16 ft) long, 30–45 cm (12–18 in) in diameter. **Leaves** numerous, straight, dark green, 1.3–1.8 m (4.3–5.9 ft) long, 24–30 cm (9.4–12 in) wide, flat, emergent leaves lightly tomentose, glabrous with age. Petiole subterete, 15–25 cm (6–10 in) long, 6–10 mm (0.2–0.4 in) in diameter, armed with spines 2 mm long spaced about 1 cm (0.4 in) apart. Leaflets in 130–170 pairs, linear lanceolate, straight to slightly falcate, abruptly narrowed at base and gradually acuminate toward the pungent apex, inserted at the midpoint of the rachis, angled forward about 55–65°, glossy green above, paler green below, median leaflets 12–20 cm (4.7–8 in) long, 5–7 mm (0.2–0.3 in) wide, margin entire, flat or slightly revolute, slightly decurrent at the attachment. **Female cones** closed type, dome shaped, about 35 cm (14 in) high and in diameter. Sporophylls 10–30 cm (4–12 in) long, each with three or four densely yellowish tomentose ovules. Lamina 9–14 cm (3.5–5.5 in) long, 7–11 cm (2.8–4.3 in) wide, densely yellowish tomentose when young, almost glabrous when mature, margin deeply and regularly pectinate, with 13–20 spines on each side, 2–5 cm (0.8–2 in) long, 2–3 mm wide. Sarcotesta dark orange-yellow to orange-red when ripe, covered with a glaucous bloom, becoming purplish red when dry. Sclerotesta elliptical to long ovoid, flattened, 40–45 mm (1.6–1.8 in) long, 22–25 mm (0.9–1 in) in diameter, light tan, the surface irregularly fissured, with two or three corky ridges running lengthwise on each side. **Male cones** solitary, erect, subcylindrical, 45–55 cm (18–22 in) long, 8–10 cm (3.2–4 in) in diameter, yellow-brown tomentose. Peduncle about 6 cm (2.4 in) long and 13 mm (0.5 in) in diameter, with several densely tomentose cataphylls surrounding its apex, the cone appearing sessile. Sporophylls angled downward from the cone axis, median sporophylls generally 35–45 mm (1.4–1.8 in) long. Sporophyll face turned upward, 7 mm (0.3 in) high, 15–20 mm (0.6–0.8 in) wide, apical spine upright, 1–3 mm long. Sporangia covering the entire lower surface of the sporophyll. **Habitat:** Exposed sites on steep shale slopes, usually with a northern exposure, at elevations of 400–900 m (1300–3000 ft), growing with other sun-loving, drought-tolerant plants. The climate is subtropical maritime with hot, humid summers, and the habitat is subjected to periodic fires. **Distribution:** Taiwan, Ta'i-tung county, only two colonies known, one in the Lu-yeh Valley near Yenping Hsiang, the other west of the Ta'i-tung Coastal Range in Tunghe Hsiang.

The history of *Cycas taitungensis,* formerly misidentified as *C. taiwaniana,* is a confused one and for this reason I feel compelled to relate it in detail. In 1893 William Carruthers described *C. taiwaniana* based on herbarium specimens from the collection of Henry F. Hance, a British consular officer in China, 1844–1886. Carruthers's description was based on a single specimen, which he described as "part of a leaf and three foliar spadices [female sporophylls] of a *Cycas* from the Island of Formosa." He added, "No more definite information is contained on the label than that the specimens were collected in the island of Formosa by Mr. Swinhoe, and sent to Dr. Hance in the autumn of 1867." In his letters to the Royal Botanic Gardens, Kew, Robert Swinhoe stated that his specimens were collected in Mainland China and made no mention of their coming from Formosa (now Taiwan). In fact, it was not until 1920 that *Cycas* was discovered on Taiwan, but because of the collection misinformation contained in Carruthers's original description of *C. taiwaniana,* it was assumed that the Taiwan plant was this species. In 1993 Kenneth D. Hill and C. J. Chen were researching *C. taiwaniana* in Mainland China while C. F. Shen and C. H. Tsou were doing the same on Taiwan. The work of these two groups was carried out independently and unknown to each other. Both groups arrived at the same conclusion, that the Mainland China and Taiwan plants are distinct species. Since the name *C. taiwaniana* is based on the mainland plants, it meant that the Taiwan species was without a valid name. These two groups of botanists joined forces and jointly described the Taiwan plant as *C. taitungensis* in 1994.

Since *Cycas taitungensis* has been misidentified for so many years as *C. taiwaniana,* we must view with suspicion the identity of all plants bearing the name *C. taiwaniana.* To my knowledge there are no specimens of *C. taiwaniana* in the United States at present. The differences between the two species are addressed in the entry for *C. taiwaniana. Cycas taitungensis* is somewhat similar to *C. revoluta* at first glance, but closer inspection discloses several differences. The leaves and leaflets are longer, broader, and flatter than those of *C. revoluta,* and the margins of the leaflets are not revolute or only slightly so. There are also differences in the female and male cones as well, but the leaf characters are sufficient to separate the species when cones are not present.

Cycas taitungensis is not common in collections, in part a result of its restricted range and scarcity in its habitat. In more recent years, sufficient seed has become available to secure the species in cultivation. Plants raised from seed prove that this cycad has a remarkably rapid growth rate in cultivation. It is not unusual for seedlings to produce several growth cycles per year, and plants 2–3 years old can produce three or more sets of leaves each year. Remarkable also is this cycad's tolerance to cold weather. In southern California, *C. taitungensis* has withstood temperatures as low as –9.5°C (15°F) without any apparent damage. In fact, it seems to withstand cold temperatures even better than *C. revoluta.* Cultivated plants have proven that *C. taitungensis* will grow well in tropical and temperate climates.

The government of Taiwan has created the 300-hectare (750-acre) Ta'i-tung Hong-yeh Village Cycas Nature Reserve to protect *C. taitungensis* in its habitat. Within the boundaries of this reserve are several hundred mature plants. Thus *C. taitungensis* can be considered as not threatened. Production of seed in habitat is good, but in recent years regeneration has been hampered by the theft of almost all seeds and seedlings by poachers. These thefts are to supply the ever increasing international demand for this cycad as an ornamental. I am aware of at least two large *ex situ* breeding colonies of *C. taitungensis,* one in Australia, another in Florida, that are now producing thousands of seeds each year. Enough artificially propagated seed should become available to supply the international market and take the pressure off wild populations.

Cycas taiwaniana Carruthers 1893

PLATE 176

Cycas revoluta var. *taiwaniana* (Carruthers) J. Schuster 1932

Cycas szechuanensis C. Y. Cheng, W. C. Cheng & L. K. Fu 1975

Cycas fairylakea D. Y. Wang in Wang & Chen 1996

The epithet for *Cycas taiwaniana* refers to Taiwan, the native name for Formosa at the time the cycad was described, when it was mistakenly thought to be native to the island. **Stems** arborescent, erect or decumbent, usually unbranched but suckering from the base, to 3.5 m (11.5 ft) long, 10–30 cm (4–12 in) in diameter, apex not tomentose. Cataphylls lanceolate, 7–13 cm (2.8–5.1 in) long, 15–18 mm (0.6–0.7 in) wide. **Leaves** numerous, straight, dark green, 1–3 m (3.3–10 ft) long, about 30 cm (12 in) wide, flat, emergent leaves lightly gray-brown tomentose, mature leaves glabrous. Petiole subterete, 0.3–1.5 m (1–4.9 ft) long, armed with 26–45 pairs of spines 1–3 mm long spaced about 15–25 mm (0.6–1 in) apart. Rachis terete. Leaflets in 76–144 pairs, linear lanceolate, straight or drooping slightly, glossy green above, paler green below, leathery, flat, with a long, pungent apex, median leaflets 18–30 cm (7.1–12 in) long, 7–13 mm (0.3–0.5 in) wide, midrib raised and prominent above and below, persistently yellowish, margins entire, flat or sometimes uneven or undulate, the lower margin decurrent. **Female cones** closed type, dome shaped, about 35 cm (14 in) high and in diameter. Sporophylls 17–25 cm (6.7–10 in) long, each with four to six ovules. Lamina rhomboid, 6–15.5 cm (2.4–6.1 in) long, 6–16 cm (2.4–6.3 in) wide, densely tan tomentose when young, almost glabrous when mature, margin deeply cut into 11–23 pairs of linear acuminate lateral divisions 15–50 mm (0.6–2 in) long, apically somewhat ovate, divisions broader, 20–50 mm (0.8–2 in) long, 3–32 mm (to 1.3 in) wide at their base, each division armed with a pungent apex. Sarcotesta red-brown when ripe. Sclerotesta more or less globose, somewhat flattened, 3–4.5 cm (1.2–1.8 in) long, 2.5–3.5 cm (1–1.4 in) in diameter, rough and warty, generally with one to four flattened longitudinal ribs. **Male cones** solitary, erect, subcylindrical to narrow ellipsoid, 49–70 cm (19–28 in) long, 9–13 cm (3.5–5.1 in) in diameter, yellow, lightly brown tomentose. Peduncle about 5 mm (0.2 in) long. Sporophylls triangular, 2–5 cm (0.8–2 in) long, 1–2 cm (0.4–0.8 in) wide. Sporophyll face somewhat flattened, apical spine not prominent, especially in the upper half of the cone. **Habitat:** Thought to have occurred in low-elevation rain forest though it has not been rediscovered in the wild. **Distribution:** China, Guangdong and Fujian provinces (?).

The history of *Cycas taiwaniana,* a cycad that in spite of its name is a native of Mainland China rather than Taiwan, is explained in the entry for *C. taitungensis.* The origin of *C. taiwaniana* has never been properly documented. It has been grown in Mainland China as an ornamental for at least 200–300 years and is still a popular and common plant in cultivation there. There were no collection data given on the type specimen, and it is generally accepted that it was collected from a cultivated plant. There are two theories on the origin of the type, one that it came from a mountainous area north of Shantou, Guangdong province, the other that it came from Xiamen, Fujian. We must accept that these are educated guesses and nothing more. The fact is that we will probably never know the exact origin of *C. taiwaniana.* In the book *Cycads in China* (1996), D. Y. Wang gave a good synopsis of what is known about *C. taiwaniana.* The general feeling is that if *C. taiwaniana* was ever part of the flora of Mainland China, it is most likely now extinct in habitat. Wang stated that *C. taiwaniana* is also from the island and province of Hainan and is possibly the same as *C. hainanensis,* though he did not cite *C. hainanensis* in synonymy under *C. taiwaniana.* Wang also illustrated his account of *C. taiwaniana* with a bewildering display of variations of megasporophylls, all supposedly from this species. Since the megasporophyll is the primary morphological character used to define species in the genus *Cycas,* it seems improbable that the wide variation shown by Wang could all be from *C. taiwaniana.*

In their 1994 description of *Cycas taitungensis,* C. F. Shen, Kenneth D. Hill, C. H. Tsou, and C. J. Chen contrasted it with *C. taiwaniana,* noting the following between the two species. In *C. taitungensis* the leaflets average 12–20 cm (4.7–8 in) long, 5–7 mm (0.2–0.3 in) wide, are slightly glossy above and dull below, have a midrib the same color as the leaflet, flat to slightly elevated above, strongly elevated and rounded below; the megasporophyll lamina is round to horizontally elliptical, its undivided central portion rhombic to broadly spindle shaped; ovules are tomentose; and the sclerotesta is irregularly grooved. In *C. taiwaniana* the leaflets average 18–30 cm (7.1–12 in) long, 7–13 mm (0.3–0.5 in) wide, are lustrous to glossy on both surfaces, have a midrib that is persistently yellowish, strongly elevated and rounded above even when dry, less elevated below and somewhat shrunken when dry; the megasporophyll lamina is trowel shaped to broadly ovate; ovules are glabrous; and the sclerotesta is rough and warty.

Cycas taiwaniana has been a popular pot and landscape plant in southern coastal China for centuries and is widely cultivated there. During that time, many thousands of plants have been collected for the ornamental plant trade. This overcollection has been so widespread and complete that *C. taiwaniana* may exist only in cultivation. For these reasons, *C. taiwaniana* must be considered extremely endangered, possibly extinct in its habitat, though common in cultivation.

Cycas tanqingii D. Y. Wang in Wang & Chen 1996

Cycas tanqingii is named in honor of Tanqing Chen, director of the Shenzhen Fairy Lake Botanical Garden, Guangdong province, China, who has promoted *ex situ* conservation and study of Chinese cycads. **Stems** arborescent, erect, to 2 m (6.6 ft) long, crown devoid of tomentum. Cataphylls lanceolate, densely tomentose. **Leaves** usually four to seven, erect, then spreading, 1.9–3.6 m (6.2–12 ft) long, 46 cm (18 in) wide. Petiole 0.8–1.6 m (2.6–5.2 ft) long, armed with 50–59 pairs of spines 1.5–3 mm long spaced 15–27 mm (0.6–1.1 in) apart. Leaflets in 57–59 pairs, linear lanceolate, gradually acuminate, glossy deep green above, pale green below, median leaflets 30–45.5 cm (12–18 in) long, 15–22 mm (0.6–0.9 in) wide, papery to leathery, midrib prominent above and below, margin flat to undulate, not revolute. **Female cones** closed type. Sporophylls 10–12 cm (4–4.7 in) long, densely red-brown tomentose, each with two ovules. Lamina round to ovate, 5–5.5 cm (2–2.2 in) long, 5–6.5 cm (2–2.6 in) wide, margin regularly pectinate with six to nine pairs of narrow, drawn-out lateral segments 15–40 mm (0.6–1.6 in) long, apical spine the same size as the lateral segments. Sarcotesta yellowish when ripe. Sclerotesta flattened globose, 3.5–4 cm (1.4–1.6 in) long, 3–3.5 cm (1.2–1.4 in) in diameter. **Male cones** solitary, erect, cylindrical, about 40 cm (16 in) long, 5–8 cm (2–3.2 in) in diameter. Peduncle short, cone appearing sessile. Sporophylls wedge shaped, 2.5–3 cm (1–1.2 in) long. Sporophyll face 10–13 mm (0.4–0.5 in) wide, apical spine upright, 1.5–2 mm long. Sporangia in a single patch covering the entire underside of the sporophyll. **Habitat:** Understory of rain forest at elevations less than 800 m (2600 ft). **Distribution:** China, Yunnan province, Luchun county, in the catchment of the Xiaoheidiang and Heishui Rivers. Vietnam, areas adjacent to the border with Yunnan province.

There is not a great deal of information on *Cycas tanqingii,* which was described in 1996. Its closest relative appears to be *C. simplicipinna* of Thailand. Both species bear two ovules on each megasporophyll, but *C. tanqingii* is said to have larger seeds and a round lamina with a short apical spine. Without locality data or female cones, these two species might be difficult to distinguish.

Apparently, *Cycas tanqingii* is only cultivated at the Shenzhen Fairy Lake Botanical Garden, Guangdong province, and at the Forestry Bureau of Luchun county, Yunnan province. It may also occur in private gardens in China but no information on this is available. No doubt this cycad would prefer tropical to semitropical climates for best growth, with some overhead cover.

The habitat of *Cycas tanqingii* covers a reasonably large area within the catchment areas of the Xiaoheijiang and Heishui Rivers. No data are available on the conservation status of this species.

Cycas tansachana K. D. Hill & S. L. Yang 1999

PLATE 177

Cycas tansachana is named in honor of Kampon Tansacha, director of the Nong Nooch Tropical Garden, Thailand, who was instrumental in the discovery of this cycad.

Stems arborescent, generally unbranched, larger specimens 2–5 m (6.6–16 ft) tall, 10–18 cm (4–7.1 in) in diameter. Cataphylls narrowly triangular, soft, 5–6 cm (2–2.4 in) long, generally with a thick covering of orange-brown tomentum, persistent. **Leaves** usually 24–60, spreading, semiglossy deep green, 1–1.7 m (3.3–5.6 ft) long, moderately keeled, apex frequently terminated by a spine 1–3 mm long, emergent leaves densely white tomentose, the tomentum loose and soon shed. Petiole 30–45 cm (12–18 in) long (20–30% of total leaf length), glabrous, unarmed or spiny to 30% of its length. Leaflets in 65–100 pairs, simple, glabrous, much lighter below than above, opposing leaflets at an angle of 90–140° to each other, producing a V-shaped cross section, spaced 10–17 mm (0.4–0.7 in) apart, basal leaflets 8–16 cm (3.2–6.3 in) long, not gradually reduced to spines, median leaflets 17–30 cm (6.7–12 in) long, 8–13 mm (0.3–0.5 in) wide, midrib flat or slightly raised above, raised below, margins slightly revolute, the lower one decurrent for 3–5 mm (to 0.2 in). **Female cones** closed type. Sporophylls 20–22 cm (8–8.7 in) long, densely brown to yellow tomentose, each with two to four glabrous ovules. Lamina nearly circular to ovate, 10–14 cm (4–5.5 in) long, 6–7 cm (2.4–2.8 in) wide, margin deeply pectinate, with 40–60 soft lateral spines 18–25 mm (0.7–1 in) long, 1–2 mm wide, apical spine distinct, 30–50 mm (1.2–2 in) long, 5–7 mm (0.2–0.3 in) wide at its base. Sarcotesta about 4 mm thick, yellow when ripe, fibrous layer present but weakly developed. Sclerotesta flattened broad ovoid, 35–38 mm (1.4–1.5 in) long, 30–32 mm (1.2–1.3 in) in diameter, the surface smooth and slightly fibrous, interior spongy layer absent. Chalaza 7–10 mm (0.3–0.4 in) in diameter, slightly projecting. **Male cones** solitary, erect, narrowly ovoid, 25–35 cm (10–14 in) long, 11–13 cm (4.4–5.2 in) in diameter, pale yellow tomentose. Peduncle short, cone appearing sessile. Sporophylls 33–45 mm (1.3–1.8 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) wide, projecting 6–15 mm (0.2–0.6 in), apical spine prominent, sharply upturned, 1–3 mm long. Sporangia in a single patch 15–25 mm (0.6–1 in) long, the sterile zone 5–7 mm (0.2–0.3 in) long. **Habitat:** Often in crevices in bare limestone cliffs and rocks, in full sun or sometimes in low scrub. **Distribution:** Thailand, known only from near Sara Buri.

Cycas tansachana was first recognized as undescribed in 1994, and described in 1999. Its distinguishing characteristics are tall arborescent stems with dark, deeply fissured bark. The closest relative of *C. tansachana* is thought to be *C. clivicola* from which it differs by its larger and distinctly keeled leaves with stiffer, broader leaflets, and larger male cones, megasporophylls, and seeds.

I am aware of no one outside Thailand who has had experience with *Cycas tansachana* in cultivation. There should be no difference between its requirements and those of other related species, such as *C. siamensis.* This species would require a tropical to subtropical climate and plenty of sun.

Cycas tansachana is locally abundant but apparently quite restricted. It has been reported as being under pressure from plant collectors and limestone mining operations and should be regarded as threatened.

Cycas thouarsii R. Brown ex Gaudichaud-Beaupré 1829

PLATES 178, 179

Cycas glauca hort. ex Miquel 1840, *C. circinalis* f. *glauca* (hort. ex Miquel) J. Schuster 1932

Cycas madagascariensis Miquel 1840, *C. circinalis* subsp. *madagascariensis* (Miquel) J. Schuster 1932

Cycas comorensis Bruant 1888

Cycas thouarsii, named in honor of Louis-Marie Aubert Du Petit-Thours (1758–1831), botanist who worked extensively in Africa and in 1804 mistakenly identified *C. thouarsii* as the Indian species *C. circinalis,* is called *samble* and *faux sagoutier* in French on Madagascar, and *fahou* or *fahu* and *voafaho* by the Betsileo tribe, *voafako, fato, fatra, fatzon,* and *batsimisaraka* by the Hova tribe, the latter name meaning man-eating plant, after a legend in which its leaves were supposed to be bloodsucking tentacles, *mtapu, mtapo,* and *mpapindi* by the Swahili in Tanzania, and *mtapu* by the Wasuaheli on Zanzibar. **Stems** arborescent, erect, usually unbranched when young but often branched in older plants, 4–10 m (13–33 ft) tall, 20–45 cm (8–18 in) in diameter. Cataphylls triangular, 6 cm (2.4 in) long, 3 cm (1.2 in) wide at the base, tomentose below, glabrous above. **Leaves** about 40 per flush in mature plants, 1.5–3 m (4.9–10 ft) long, 30–60 cm (12–24 in) wide. Petiole terete, 30–40 cm (12–16 in) long, armed with spines 5 mm (0.2 in) long. Leaflets in 60–70 pairs, bright green above, paler below, glabrous, leathery, with an acute apex, median leaflets subfalcate to linear, 20–38 cm (8–15 in) long, 7–20 mm (0.3–0.8 in) wide, abruptly reduced at the base, midrib prominent above and below, margins entire and slightly revolute, the lower one decurrent. **Female cones** open type. Sporophylls pendent when seed ripe, to 35 cm (14 in) long, densely orange-brown tomentose, each with 8–10 ovules. Lamina ovate to lanceolate acuminate, 7–10 cm (2.8–4 in) long, 3 cm

(1.2 in) wide, margin subentire to minutely scalloped or irregularly toothed. Sarcotesta brick red when ripe. Sclerotesta broad ovoid, slightly flattened, 47–54 mm (1.8–2.1 in) long, 37–44 mm (1.5–1.7 in) in diameter, the surface more or less smooth. **Male cones** solitary, erect, oblong cylindrical, 30–60 cm (12–24 in) long, 11–20 cm (4.3–8 in) in diameter, densely yellowish orange tomentose. Peduncle usually less than 5 cm (2 in) long, lightly tomentose. Sporophylls wedge shaped, 3.5–5 cm (1.4–2 in) long. Sporophyll face about 2 cm (0.8 in) wide, apical spine gently upturned, 3–8 mm (to 0.3 in) long. Sporangia in a heart-shaped patch. **Habitat:** Solitary or in small groups in open woodland and forest margins, generally on sand and coral formations, usually near the coast. Rainfall is generally 2000–3000 mm (79–120 in) annually. Summer temperatures are relatively high, and winters frost-free. **Distribution:** Africa, along the coasts of Mozambique, Tanzania, and Kenya. Madagascar, eastern coastal areas. Comoro Islands. Also introduced into Mauritius and the Seychelles.

There have been many theories regarding the distribution of *Cycas thouarsii* in areas other than Madagascar, where it was first described. Some botanists hold that its occurrence on the eastern coast of Africa is a result of introduction by Arab traders. To support this theory, they point out that no large stands of this cycad have been found in habitats there. Since this species has been used both as a food item and for decoration, it is conceivable that it was introduced for those purposes. Almost certainly, this species was introduced into Mauritius and the Seychelles. There may also be some doubt about the *Cycas* from the Comoro Islands (formerly *C. comorensis*) as being *C. thouarsii.* Pant and Nautiyal (1963) discovered distinctive differences between the leaf anatomy of *C. thouarsii* and *C. comorensis.* There is little doubt that more research is necessary to evaluate the various species of *Cycas* properly.

Some mention has been made in the literature regarding economic uses of *Cycas thouarsii.* It has been noted that mature leaves are woven into mats, that young, tender, emergent leaves are used as a vegetable, and that a starchlike meal is made from the seeds and stems.

Cycas thouarsii does very well in cultivation in the Tropics and sub-Tropics. For this cycad to do best it must have plenty of heat and some humidity. It has been grown in some areas with a Mediterranean climate, but it does not do as well as in the Tropics. In areas of low humidity, this cycad should be protected from midday and afternoon sun. Artificial shade or the open shade of trees promotes reasonable growth and keeps the foliage green. Too much sun in areas of low humidity will cause yellowing of leaves and an overall unhealthy appearance. *Cycas thouarsii* has a very rapid growth rate, and when grown from seed a handsome specimen is possible in just a few years. Under optimal climatic or greenhouse conditions, as many as three or four growth cycles can be expected each year, each one adding to the trunk height. As one would expect from its tropical habitat, *C. thouarsii* is not frost hardy. It is frost tolerant to about 0°C (32°F) for short periods, but below freezing, foliar burn or defoliation can be expected, sometimes followed by the death of the entire plant.

Not a great deal of information is available on the conservation status of *Cycas thouarsii.* It is evidently not common in any part of its range and seemingly must eventually suffer the same fate as plants worldwide through continuing habitat destruction.

Cycas tropophylla K. D. Hill & S. L. Yang in Hill et al. 2002

The epithet for *Cycas tropophylla* is derived from *tropis,* Greek for boat keel, and *phyllon,* leaf, referring to the distinctively keeled leaves. **Stems** subterranean to arborescent, to 1 m (3.3 ft) long, 8–15 cm (3.2–6 in) in diameter. Cataphylls narrowly triangular, soft, lightly tomentose, 3–5 cm (1.2–2 in) long, persistent. **Leaves** generally 10–30, semiglossy, deep green or gray-green, 0.7–1.2 m (2.3–3.9 ft) long, moderately to strongly keeled, emergent leaves densely brown tomentose, becoming glabrous with age. Petiole 10–35 cm (4–14 in) long (15–30% of total leaf length), glabrous, unarmed or spiny 5–80% of its length. Rachis consistently terminated by paired leaflets. Leaflets in 50–85 pairs, much lighter below than above, basal leaflets 5–8 cm (2–3.2 in) long, not gradually reduced to spines, median leaflets 12–18 cm (4.7–7 in) long, 7–12 mm (0.3–0.5 in) wide, angled forward 40–70°, opposing leaflets at an angle of 90–120° to each other, producing a V-shaped cross section, narrowed to 2.5–3.5 mm at the base, spaced 10–16 mm (0.4–0.6 in) apart, decurrent for 2–6 mm (to 0.2 in), midrib raised above and below, margin flat or curved slightly backward and downward. **Female cones** closed type. Sporophylls 8–12 cm (3.2–4.7 in) long, densely brown tomentose, each with two to six glabrous ovules. Lamina rounded, 9–12 cm (3.6–4.7 in) long, 6–6.5 cm (2.4–2.6 in) wide, deeply pectinate, with 24–34 soft lateral spines 2.5–3.5 cm (1–1.4 in) long, 2–3 mm wide, apical spine distinct, 4–4.5 cm (1.6–1.8 in) long, 4–6 mm (0.2 in) wide at its base. Sarcotesta 1–2 mm thick, yellow, not glaucous, fibrous layer absent. Sclerotesta ovoid, smooth to rough and warty, 20–28 mm (0.8–1.1 in) long, 18–25 mm (0.7–1 in) wide, spongy endocarp absent. **Male cones** solitary, narrowly ovoid to spindle shaped, 15–30 cm (6–12 in) long, 5–8 cm (2–3.2 in) in diameter, orange. Sporophylls 20–30 mm (0.8–1.2 in) long, 11–15 mm (0.4–0.6 in) wide. Sporophyll face 2–4 mm long, apical spine rudimentary or absent, when present sharply upturned, to 3 mm long. **Habitat:** Limestone bluffs above the ocean, generally in cracks and crevices on bare limestone faces with no soil accumulation at the roots. **Distribution:** Vietnam, northern part of the country, in and around Haiphong Harbor, on Cát Bà Island and other nearby islands, and the adjacent mainland.

Although *Cycas tropophylla* is a distinctive species it was completely overlooked for many years. Its keeled leaves make it unique among the northern Vietnamese species of the genus. *Cycas tropophylla* shows the same habitat preference as *C. ferruginea, C. revoluta,* and *C. sexseminifera,* growing on bare limestone cliff faces or steep limestone bluffs with virtually no soil accumulation at the root zone. *Cycas tropophylla* is closely allied to *C. sexseminifera* but can be immediately distinguished from that species by its keeled leaves. It also differs in its generally larger proportions and the larger, broader megasporophyll lamina with its distinctive broad apical spine.

Cycas tropophylla, because of its small size and deep green keeled leaves, is a handsome species well suited for use as a landscape or pot plant. This is another species that has not yet been introduced into cultivation outside Vietnam, but because of its decorative potential I have no doubt that it will become available. It is best suited for tropical and subtropical climates and would no doubt demand good drainage to maintain healthy growth. The genus *Cycas* appears to have a genetically based resistance to cold damage, and many tropical species grow quite well in temperate climates. It is hoped that *C. tropophylla* will prove to be a good candidate for temperate and warm temperate areas.

The conservation status of *Cycas tropophylla* appears to be reasonably secure. This is no doubt the result, in part, of its protection from collectors through its occurrence on small islands off the coast of northern Vietnam. *Cycas tropophylla* can be considered not threatened.

Cycas tuckeri K. D. Hill 1996

PLATE 180

Cycas tuckeri is named in honor of Robert Tucker (1955–1992), director of the Parks and Gardens Department of Townsville, Queensland, Australia, and an avid explorer of the Cape York Peninsula, where he found this cycad and recognized it as distinct. **Stems** arborescent, erect, to 4 m (13 ft) long, rarely as long as 6 m (20 ft), 16–24 cm (6.3–10 in) in diameter. Cataphylls not pungent but finely gray-white tomentose, narrowly triangular, 5–8 cm (2–3.2 in) long. **Leaves** numerous, spreading, 0.9–1.5 m (3–4.9 ft) long, slightly keeled, sometimes terminated by a spine 2–5 mm (to 0.2 in) long, emergent leaves loosely orange-brown tomentose. Petiole unarmed, 20–45 cm (8–18 in) long, loosely orange-brown tomentose. Leaflets in 50–100 pairs, glossy dark green, median leaflets 15–25 cm (6–10 in) long, 7–9 mm (0.3–0.4 in) wide, angled forward 40–50°, opposing leaflets at an angle of 90–140° to each other, producing a V-shaped cross section, spaced 10–17 mm (0.4–0.7 in) apart, midrib slightly raised above, prominent below, margins curved backward and downward, the lower one decurrent for 2.5–3.5 mm. **Female cones** open type. Sporophylls 10–14 cm (4–5.5 in) long, gray tomentose, each with two to four ovules. Lamina ovate, 50–65 mm (2–2.6 in) long, 38–50 mm (1.5–2 in) wide, margin regularly toothed, with 22–36 lateral spines 1–4 mm long, apical spine 19–30 mm (0.8–1.2 in) long. Sarcotesta orange when ripe. Sclerotesta flattened ovoid, 28–34 mm (1.1–1.3 in) long, 26–32 mm (1–1.3 in) in diameter. **Male cones** solitary, erect, narrow ovoid, 30–35 cm (12–14 in) long, 13–15 cm (5.1–6 in) in diameter, rusty brown tomentose. Peduncle short, cone appearing sessile. Sporophylls 40–42 mm (1.6–1.7 in) long. Sporophyll face 5–9 mm (0.2–0.4 in) high, 12–15 mm (0.5–0.6 in) wide, not curved backward and downward, apical spine slender, sharply upturned, 10–16 mm (0.4–0.6 in) long. Sporangia in a single patch covering the underside and sides of the sporophyll. **Habitat:** Low-elevation open savanna woodland dominated by *Eucalyptus cullenii,* in soils that are granitic in origin and gritty to rocky. **Distribution:** Australia, Queensland, known only from the one small population at the type locality in the Coen district.

Cycas tuckeri was described in 1996 from the Cape York Peninsula of Queensland, Australia. To my knowledge it has not yet been tried in cultivation, even in Australia. It can be expected to require tropical or at least subtropical climatic conditions for optimal growth. The medium size and handsome leaves of this species might make it a popular collector's item.

Cycas tuckeri is known only from a very restricted and limited population. It must be considered endangered, one of the rarest species of Queensland *Cycas* and potentially at risk of extinction.

Cycas wadei Merrill 1936

PLATE 181

Cycas circinalis f. *graminea* J. Schuster 1932

Cycas wadei is named in honor of Dr. H. Windsor Wade (b. 1886), who provided material and information used in naming and describing this cycad. **Stems** arborescent, erect, solitary or often branched, not suckering, to 5.3 m (17 ft) high but usually much shorter, 30–48 cm (12–19 in) in diameter at the base, 10–20 cm (4–8 in) in diameter below the crown of leaves, the aerial trunk with pronounced growth rings around it, the swollen base tapering abruptly in the lower 20–45 cm (8–18 in) and much more gradually above. Plants may reach sexual maturity, coning size, when less than 30 cm (12 in) high and 15 cm (6 in) in diameter. **Leaves** numerous, slightly arching, 0.8–1.1 m (2.6–3.6 ft) long, 20–30 cm (8–12 in) wide, slightly keeled. Petiole more or less round, 20–30 cm (8–12 in) long, 5–10 mm (0.2–0.4 in) in diameter, with two rows of spines about 1.5 mm long spaced about 6 mm (0.2 in) apart. Leaflets closely set in about 90 pairs, linear to linear lanceolate, leathery, rigid, straight or somewhat falcate, smooth, sharply acuminate, basal and apical leaflets about 8 cm (3.2 in) long, the lower ones not reduced to spines, median leaflets 15–20 cm (6–8 in) long, 4–5 mm (0.2 in) wide, broadly keeled, margin straight and flat. **Female cones** closed type. Sporophylls to 22 cm (8.7 in) long, densely red-brown tomentose, each with two glabrous, shining ovules, rarely more, the sporophyll stem about 15 cm (6 in) long and 1 cm (0.4 in) wide. Lamina ovate, about 10 cm (4 in) long and 8 cm (3.2 in) wide, pectinate, pinnatifid with about 15 lobes to 3.5 cm (1.4 in) long on each side, the lobes ascending, rigid, linear, sharp pointed, usually glabrous above and tomentose below but sometimes entirely glabrous. Sarcotesta brown to orange-brown when ripe. Sclerotesta ovoid to globular, 32–40 mm (1.3–1.6 in) long, 25–30 mm (1–1.2 in) in diameter, somewhat glossy, pale brown, with 9–15 longitudinal ribs that are prominently raised. **Male cones** solitary, erect, long conical, 40–70 cm (16–28 in) long, 9–10 cm (3.5–4 in) in diameter, narrowed below and tapering above, reddish brown tomentose. Peduncle short, cone appearing sessile. Sporophylls about 3 cm (1.2 in) long. Sporophyll face densely tomentose, 1 cm (0.4 in) high, 1.5–2 cm (0.6–0.8 in) wide, strongly ascending, apical spine 5–6 mm (0.2 in) long. **Habitat:** Usually under low trees or bushes bordering large open grassy areas, at low elevations, in more or less dry conditions. The climate is tropical, and rain generally falls during summer. **Distribution:** Philippines, island of Culion in the Calamian Group, said to be limited to an area approximately 5 km (3 miles) wide and long, to the east of Halsey Harbor.

Cycas wadei was discovered on Culion by Elmer Drew Merrill on February 11, 1902, during a one-day trip inland from Halsey Harbor. The object of the trip was to look over a large, open, grassy area originally selected as the possible site for the Culion leper colony. In the northern part of the area, a number of *Cycas* plants were observed. These plants were examined but no evidence of cones could be found. Merrill had to content himself with collecting a few leaf specimens that he took back to the Gray Herbarium, Harvard University. In 1908 Merrill compared these specimens with numerous *Cycas* specimens at the Royal Botanic Gardens, Kew. He felt that the Culion plants were closest to *C. cairnsiana* of Australia and provisionally placed them under that name.

In the ensuing years, Merrill tried without success to have additional material collected. It was April 1923 when two physicians from the Culion Leper Colony (which had been constructed on the opposite side of the island) were able to rediscover these cycads for Merrill. After a 7-hour hike, Drs. H. Windsor Wade and G. A. Perkins located the plants and collected the needed materials. Merrill forgot about this cycad for some years until the arrival of additional material in 1931. He then proceeded with finalizing the description of *C. wadei,* which was published in 1936.

Cycas wadei is rare in collections, and in some cases plants referred to this species have been misidentified. The seeds of *C. wadei* are distinctive in that they have 9–15 longitudinal ribs running the entire length of the sclerotesta. This feature is restricted to the seeds of *C. wadei* and *C. curranii,* both from islands in the vicinity of Palawan. Also distinctive are the alternating raised and depressed growth rings exhibited by older stems of *C. wadei.* This feature is not unique to *C. wadei,* as I have seen it in *Microcycas, Dioon,* and a few other species of *Cycas.* Two other features that make *C. wadei* a remarkable plant are its narrow leaflets and long petiole, which give the leaf a distinctive appearance.

Cycas wadei is easily grown but does not exhibit the rapid growth usually associated with tropical species of *Cycas.* Given the general requirements of well-drained soil and ample fertilizer, *C. wadei* will thrive in cultivation. It is slightly sensitive to frost or cold growing conditions, as expected of a plant from the Tropics. In my collection, small specimens of *C. wadei* have grown well even with annual frosts. Some leaf burn is usually evident at the end of the cold season, and complete defoliation has occurred on two occasions of extremely cold weather, but new leaves were produced with the advent of spring and warming temperatures.

Not a great deal is known about the conservation status of *Cycas wadei.* In 1941, Dr. Wade wrote in a letter to David Barry Jr. of Los Angeles, California, "Certainly few seedlings are to be found in their natural habitat, but that may be due to the impenetrability of the ground—to say nothing of the annual grass fires and possible activity of the wild hogs." Grass fires and the rooting of hogs are generally accepted as being adverse to seed and seedling survival. I have been informed that numerous mature specimens were destroyed when an airfield was constructed on the flat grassy area adjacent to the main colony of plants. The land on which the entire colony of *C. wadei* occurs is privately owned and has been burned to convert it to grassland for cattle grazing. The cycads have survived and are growing and reproducing. The owner had proposed the eradication of the cycads and the development of the land but had given up the idea because there was no steady water supply. One must consider *C. wadei* to be extremely endangered if the small colony on Culion is in fact the only population, and steps should be taken to ensure its survival.

Cycas xipholepis K. D. Hill 1996

The epithet for *Cycas xipholepis* is derived from *xiphos,* Greek for sword, and *lepis,* scale, referring to the long, hard, pungent cataphylls. Stems arborescent, erect, to 3 m (10 ft) tall, rarely as tall as 8 m (26 ft), 10–15 cm (4–6 in) in diameter. Cataphylls 8–14 cm (3.2–5.5 in) long, stiff, pungent, densely gray tomentose. Leaves numerous, erect to spreading, 0.7–1.2 m (2.3–3.9 ft) long, 15–30 cm (6–12 in) wide, emergent leaves densely white and orange-brown tomentose. Petiole 23–35 cm (9.1–14 in) long, glabrous, unarmed or sometimes spiny 5–50% of its length. Leaflets in 50–105 pairs, glabrous, glossy dark green, lighter below than above, flat, median leaflets 7.5–15 cm (3–6 in) long, 4.5–7 mm (to 0.3 in) wide, angled forward 70–90°, opposing leaflets at an angle of 160–180° to each other, thus almost in the same plane, spaced 6–9 mm (0.2–0.4 in) apart, midrib prominent above and below, margins flat, the lower one decurrent for 1.5–3 mm. Female cones open type. Sporophylls 15–27 cm (6–11 in) long, densely gray-orange tomentose, each with two to six ovules. Lamina triangular, 40–65 mm (1.6–2.6 in) long, 20–29 mm (0.8–1.1 in) wide, regularly toothed, with 16–34 lateral teeth 5–7 mm (0.2–0.3 in) long, apical spine 17–24 mm (0.7–0.9 in) long. Sarcotesta orange, slightly glaucous when ripe. Sclerotesta flattened ovoid, 33 mm (1.3 in) long, 28 mm (1.1 in) in diameter. Male cones solitary, ovoid, about 20 cm (8 in) long and 8 cm (3.2 in) in diameter, orange-brown tomentose. Peduncle short, cone appearing sessile. Sporophylls about 2 cm (0.8 in) long. Sporophyll face about 14 mm (0.6 in) wide, projecting 6 mm (0.2 in), apical spine slender, sharply upturned, about 1 cm (0.4 in) long. Habitat: Savanna forests dominated by *Eucalyptus tetrodonta,* on deep white or yellow sands over laterites or on low stony laterite hills. Distribution: Australia, Queensland, central Cape York Peninsula, south of Coen to Batavia Downs, west to Merapah.

When the late John R. Maconochie was in the process of revising the genus *Cycas* in Australia, he was of the opinion that *Cycas xipholepis* constituted a disjunct colony of *C. armstrongii.* This opinion was no doubt based on the small diameter of the stems and the hard spinelike cataphylls, both characteristics found in *C. armstrongii. Cycas xipholepis* is relatively easy to distinguish from other species on the Cape York Peninsula by its dark green leaves, long petioles, flat leaflets with the midrib equally prominent above and below, but especially by the long, hard, spinelike cataphylls.

I am not aware of any information on the cultivation of *Cycas xipholepis.* It should not be any more difficult to grow than the other tropical species of the genus. The slender stems of *C. xipholepis* coupled with the dark green leaves provide a combination capable of producing a remarkably handsome landscape and garden plant. There is no doubt that *C. xipholepis* could become a very popular item for collectors and gardeners once propagation material is commonly available.

Cycas xipholepis is widespread in the Cape York Peninsula and locally abundant. Most of the known populations are in remote country, and for these reasons the species is not considered to be at risk.

Cycas yorkiana K. D. Hill 1996

PLATE 182

The epithet for *Cycas yorkiana* refers to the Cape York Peninsula, Queensland, Australia, where this cycad occurs. Stems arborescent, erect, to 1.5 m (4.9 ft) long, rarely as long as 3 m (10 ft), 14–20 cm (5.5–8 in) in diameter. Cataphylls soft, 6–8 cm (2.4–3.2 in) long, densely orange-brown woolly. Leaves numerous, spreading, 0.9–1.4 m (3–4.6 ft) long, openly keeled, terminated by a spine 5–20 mm (0.2–0.8 in) long, emergent leaves densely orange-brown tomentose. Petiole orange-brown woolly, 15–30 cm (6–12 in) long. Leaflets in 80–110 pairs, glossy medium green, usually falcate, keeled, narrowed to 4–5 mm (0.2 in) at the base, decurrent for 3–5 mm (to 0.2 in), median leaflets glabrous, 14–20 cm (5.5–8 in) long, 5.5–7.5 mm (0.2–0.3 in) wide, angled forward 60–75°, opposing leaflets at an angle of 150–180° to each other, thus almost in the same plane, spaced 9–11 mm (0.4–0.5 in) apart, apex gradually drawn out, midrib slightly raised above, prominent below, margin straight, curved slightly backward and downward. **Female cones** open type. Sporophylls 20–32 cm (8–13 in) long, gray and orange tomentose, each with two to six ovules. Lamina narrowly triangular, 6–10 cm (2.4–3.9 in) long, 16–32 mm (0.6–1.3 in) wide, regularly toothed, with 24–32 lateral teeth 3–6 mm (to 0.2 in) long, apical spine 11–18 mm (0.4–0.7 in) long. Sarcotesta orange when ripe. Sclerotesta flattened ovoid, 28–37 mm (1.1–1.5 in) long, 26–32 mm (1–1.3 in) in diameter. **Male cones** solitary, erect, about 20 cm (8 in) long and 9 cm (3.6 in) in diameter, orange-brown tomentose. Sporophylls about 3.5 cm (1.4 in) long. Sporophyll face about 12 mm (0.5 in) wide, apical spine about 6 mm (0.2 in) long. **Habitat:** Flat country on sandy soils in the understory of *Eucalyptus miniata* and *E. tetrodonta* forest. **Distribution:** Australia, Queensland, northern Cape York Peninsula, abundant but localized within the area to the north of the Wenlock River.

In cultivation, *Cycas yorkiana,* because of its tropical habitat, not surprisingly is best suited to tropical and subtropical climates. Seedlings that I have grown in a Mediterranean climate in southern California have not prospered. Under greenhouse conditions, growth was reasonably rapid and the plants were healthy, but planted outdoors, the cold, wet winters were not to their liking. In general, *C. yorkiana* has a nice appearance and a compact growth habit but is not unlike several other of the species from the Cape York Peninsula. I know of no gardens where this species is in cultivation.

The conservation status of *C. yorkiana* is secure because of the abundance of plants in habitat. Its distribution, however, is very localized, and this could lead to a rapid change in its status through land clearance.

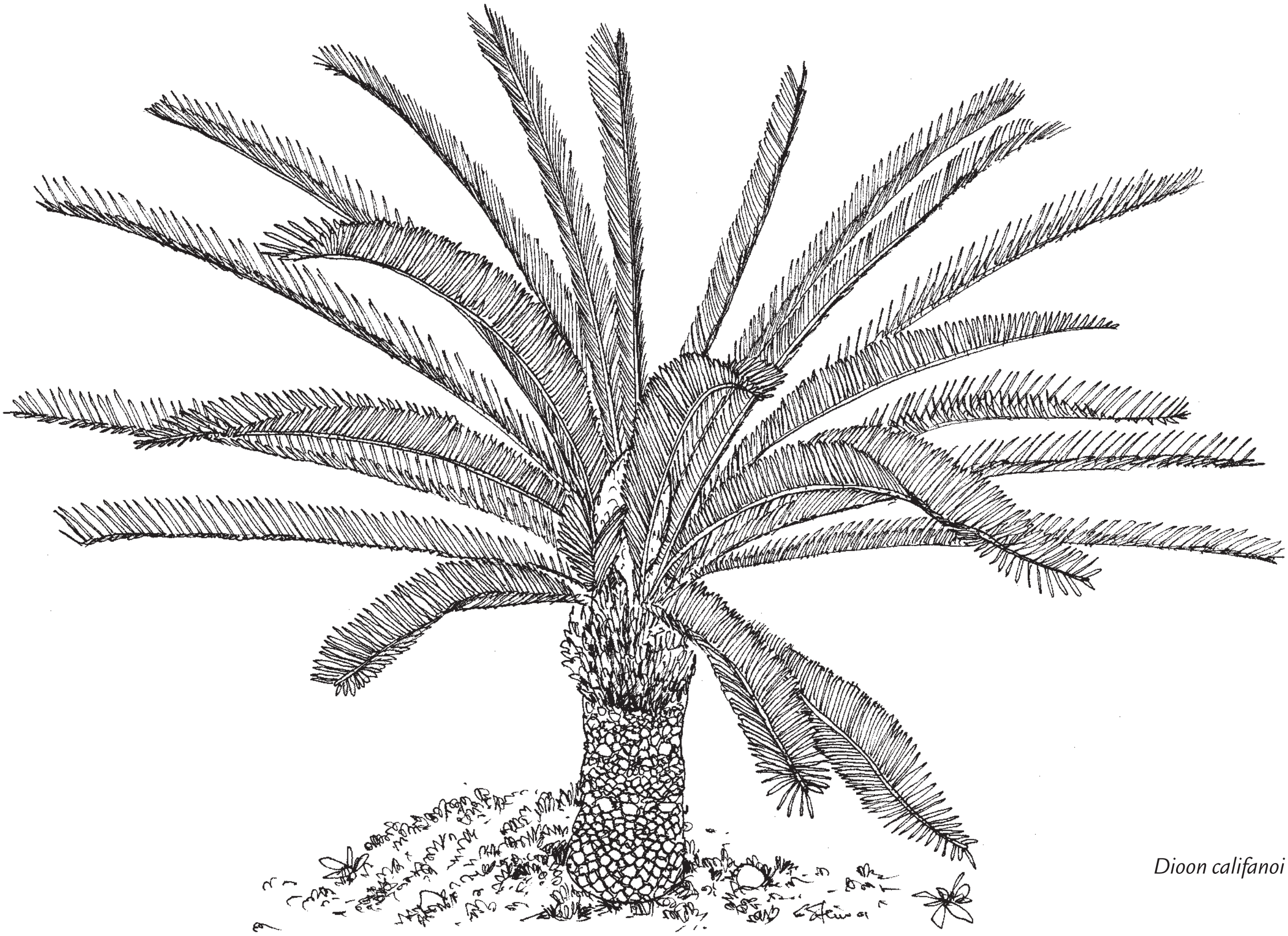
Dioon Lindley 1843

Platyzamia Zuccarini 1845

The name *Dioon* is derived from the Greek and means two eggs, referring to the two seeds attached to each female sporophyll. John Lindley spelled it *Dion*; Friedrich Anton Wilhelm Miquel corrected the spelling to *Dioon* in 1846, and that spelling has been conserved by the *International Code of Botanical Nomenclature.* Eleven species (type, *D. edule*) with the distinct possibility of others as new populations are studied. Chromosome number 2*n* = 18. *Dioon* together with most of the other cycad genera constitute the family Zamiaceae.

Stems among the tallest of the cycads, second only to *Lepidozamia* in maximum trunk length. Individuals of *Dioon spinulosum* have been recorded to attain a height of more than 15 m (49 ft). Of course, these are exceptionally old specimens and trunks of that size are rare. Generally, a height of 7.5–10.5 m (25–34 ft) is considered a very large specimen. More than half of the species of *Dioon* do not approach this great size and could be considered of small to medium stature. Very old specimens of the *D. edule* group are often leaning or decumbent and occasionally serpentine in habit. As with many other genera of cycads, dioons are clothed in a thick armor of old leaf bases that protect them from the frequent fires that pass through their habitat. Their trunks are also thickly tomentose, the tomentum persistent until burned off. The diameter of *Dioon* stems ranges from about 10–15 cm (4–6 in) in *D. spinulosum* to fairly thick at about 20–30 cm (8–12 in) in several other species.

Leaves generally 1–2 m (3.3–6.6 ft) long, 7.5–20 cm (3–8 in) wide, usually stiff and straight in most species but somewhat flexible and arching in *Dioon mejiae, D. rzedowskii,* and *D. spinulosum,* dull glaucous green to glossy green, leaflet arrangement varying from flat to keeled, some leaflets inserted into the rachis flat, others overlapping. The number of leaves produced by a mature plant averages about 15 but may be more or less depending on growth conditions. The leaves are tough and normally persist as long as 4 years if not burned off or otherwise



Dioon califanoi

damaged. In some species, leaf production does not take place annually and the interval between the emergence of new leaves may be as long as 2–3 years. In many cases, cones are produced instead of leaves, and in the extreme new leaves will not be produced until after the death of the old crown. Leaflets may be entire or have marginal spines or teeth. Generally, all dioons from the east coast of Mexico except *D. spinulosum* have no marginal spines whereas all the central and west coast species have leaflets with marginal spines. The exceptions to this rule are seedlings of all species, which have leaflets with marginal spines in the juvenile stage.

Female cones quite distinctive and not easily mistaken for the cones of any other cycad genus. A single cone is produced at each reproductive cycle, generally every 3–4 years. As the cones often take more than a year to mature, sometimes two cones will be seen on a single plant, but these are always from two seasons. The cones are heavily tomentose and usually egg shaped to slightly cylindrical. The coating of tomentum completely covers the exposed surface of the cone except for the basal one or two rows of sporophylls in some species. These glabrous sporophylls open during the cone's receptive stage, allowing the entrance of the pollinator, a small weevil. Artificial pollination is made extremely difficult by the heavy and almost impenetrable coating of tomentum on the female cone. Because of the cone's structure it is not feasible to cut off the top to introduce the pollen. The sporophylls with their ascending wedge-shaped outer surface make the cone somewhat like an artichoke in shape and structure. Like an artichoke, if the top is cut off to expose the basal portions of the sporophylls, a large part of the cone must be removed. This could result in the death of the cone. A dust gun with a small nozzle can be inserted into the openings at the base of the cone to blow pollen into the interior spaces. This method usually results in some viable seed, but the percentage of good seed is generally low. When the female cone breaks up at maturity, which can be from 8 months to almost 2 years in some species, viable seed is easily identified. Seeds that have not been fertilized will not fully develop. Unfertilized seed will be undeveloped and very small.

Male cones solitary, produced irregularly, usually September–November, elliptical to ovoid, varying from small, about 10 cm (4 in) long, to large, about 45 cm (18 in) long, the exterior surface usually with a coating of tomentum but in some species the lower half of the sporophyll face glabrous with only the apex tomentose, in some species this coating thin and in others quite dense. Sporangia generally covering the entire undersurface of the sporophyll but in some cases with an open area down the center separating them into two patches. In mature cones during pollen shedding there is a noticeable temperature rise, and a strong musty smell is produced. These two phenomena are doubtless linked to attracting the insect pollinators.

Habitat: Most species, those of the *Dioon edule* complex, occur in dry rocky areas from sea level to more than 2100 m (7000 ft). A number of these habitats are dry enough to be classed as true desert, including the growing areas of *D. califanoi, D. caputoi, D. sonorense,* and some habitats of *D. merolae. Dioon spinulosum* and its two allies *D. mejiae* and *D. rzedowskii* inhabit the margins or interior of true rain forest. They are able to grow in low light intensities and on poor soils. This may not always have been their situation, as plants with trunks tall enough to emerge above the tree canopy always seem to be more robust than their shaded counterparts.

Distribution: Mexico except for *Dioon mejiae* (Honduras), generally restricted to the coastal mountain chains, the Sierra Madre Occidental in the west and Sierra Madre Oriental in the east.

Even though the range of *Dioon* in Mexico is quite extensive, it cannot be considered a common plant. *Dioon,* like most other cycads, is found in scattered colonies where it may be locally common, but generally not over a large area. In the case of *D. caputoi* there are two small colonies with the total number of individuals estimated to be roughly 100. *Dioon mejiae* and *D. spinulosum* are the only species with many thousands of plants scattered over a fairly large area. The discovery of *D. mejiae* in Honduras, far removed from its relatives in Mexico, was an unexpected surprise. *Dioon mejiae* is more closely related to *D. rzedowskii* and *D. spinulosum,* though the uniqueness of its large, strangely shaped, deeply fissured seeds sets it apart from all other dioons. Like *D. rzedowskii* and *D. spinulosum, D. mejiae* has a pendent female cone.

As garden plants, most species of *Dioon* are easily cultivated and grow with minimal care. They are frost tolerant to several degrees below freezing, but lower temperatures will cause foliar damage or complete defoliation. High temperatures and full sun do not usually cause damage, even to forest-dwelling species such as *D. spinulosum.* In my garden, *D. spinulosum* grows more rapidly and appears healthier in full sun than in shade. Applications of fertilizer throughout the growing season are welcomed by dioons, and they respond by producing larger numbers of leaves of a much richer green. The only insect pests that generally infest dioons are scale insects. Plants grown in too much shade often develop infestations of scale insects and mealybugs, but they are easily eradicated by spraying with the proper insecticide. Like all other cycads, well-drained soil is essential. The addition of dolomite lime to the soil is beneficial to all dioons as they generally grow in limestone areas.

The conservation status of most species of *Dioon* is secure. Exceptions are *D. califanoi* and *D. caputoi,* which must be considered extremely endangered because of the small number of plants remaining in habitat. Regeneration by seed and the survival rate of seedlings in most species are very good. The implementation of CITES has stopped the export of dioons from Mexico, but in more recent years, increasing numbers of them have been used in gardening and landscaping within Mexico. Another use is the cutting off of the stem apex, which is then sold as a table decoration. If this practice is allowed to continue, several species of *Dioon* could soon become endangered. Conservation of *Dioon* is also impeded by the continual demand for more agricultural land that necessitates the clearing of large tracts of native vegetation. We must hope that the Mexican government will control this large-scale destruction of habitat, ensuring the survival of *Dioon* in the wild. All species of *Dioon* are listed in Appendix II of CITES.

Dioon califanoi De Luca & Sabato 1979

PAGE 159, PLATES 183–185

Dioon califanoi is named in honor of Luigi Califano (1901–1976) of the Accademia Nazionale dei Lincei, Italy, who introduced Paolo De Luca and Sergio Sabato to the dioons of Mexico. **Stems** cylindrical, to 3 m (10 ft) long or more, 20–30 cm (8–12 in) in diameter. Cataphylls densely tomentose, 9–10 cm (3.5–4 in) long, 2 cm (0.8 in) wide. **Leaves** numerous, straight to slightly arching, rigid, glaucous gray, 75–85 cm (30–34 in) long, 9–16 cm (3.5–6.3 in) wide, strongly keeled, emergent leaves tomentose, glabrous with age. Petiole semiterete, 10–12 cm (4–4.7 in) long. Rachis semiterete and often twisted at the apex. Leaflets in 80–100 pairs or more, linear lanceolate, spine-tipped, extremely stiff, inserted above the middle of the rachis and overlapping in an upward direction, spaced about 5 mm (0.2 in) apart, reduced in size toward the base but not to prickles, median leaflets 6–7 cm (2.4–2.8 in) long, 7–8 mm (0.3 in) wide, margin entire in adult plants, in immature plants entire or with one to three spines. **Female cones** solitary, ovoid cylindrical, 40–50 cm (16–20 in) long, 20–25 cm (8–10 in) in diameter, densely tomentose. Peduncle short, cone appearing sessile. Sporophylls about 10 cm (4 in) long. Sporophyll face triangular, erect, 6–7 cm (2.4–2.8 in) high, 5–6.5 cm (2–2.6 in) wide, densely tan tomentose. Sarcotesta yellow when ripe. Sclerotesta more or less round to irregularly ovoid, 3–4 cm (1.3–1.6 in) long, 2–2.5 cm (0.8–1 in) in diameter, the surface smooth except for 8–12 indistinct and shallow longitudinal grooves. Chalaza slightly protruding around a pit 2–3 mm in diameter. **Male cones** solitary, elongate cylindrical, 30–40 cm (12–16 in) long, 8–10 cm (3.2–4 in) in diameter, gray-green with a small patch of light brown tomentum at the apex of each sporophyll, apex blunt. Peduncle 2–3 cm (0.8–1.2 in) long, 1.5 cm (0.6 in) in diameter, the cone often appearing sessile. Sporophyll face triangular, 15–25 mm (0.6–1 in) high, 15–18 mm (0.6–0.7 in) wide, gray-green with a small patch of light brown tomentum at its apex. Sporangia in a single patch covering the entire undersurface of the sporophyll. **Habitat:** High desert at elevations of 2000–3250 m (6600–10,600 ft) in association with cacti, other succulents, *Agave, Bursera, Tillandsia,* and dwarf oaks, usually on steep slopes in full sun but sometimes in the shade of stunted oaks, in soil that is generally rocky and poor. The scant rainfall occurs only in summer. Summers are hot, and winters cool to cold with frequent frosts. **Distribution:** Mexico, Puebla state, above Teotitlán del Camino on the road to Huautla de Jiménez.

Dioon califanoi was known for many years before it was described in 1979. It had been mistaken for *D. edule* by its original collectors, and this error was not to be noticed until a group of Italian botanists studied the herbarium specimens in detail some years later. For some time before its description, collectors referred to this cycad as *Dioon* "V" because its leaves are keeled or V shaped in cross section. *Dioon califanoi* is closely related to *D. purpusii,* with which it could be easily confused. The leaves of *D. califanoi,* however, are more heavily keeled and arching, and the leaflets generally spineless in adults. In *D. purpusii,* leaves are only slightly keeled and straight, both margins of adult leaflets usually bear spines, and the tomentum on the leaf surface persists about a year.

In habitat, very old plants of *Dioon califanoi* usually have reclining stems. Stems of younger specimens are upright to slightly leaning. Because of the steep hillsides the plants inhabit, the base of the stem is usually deeply embedded in the ground. This is caused by soil washing down and building up against the stem. The leaves are gray to gray-green, extremely stiff, and leathery. One would think that leaves this tough would be impervious to damage by predators, but that is not the case. In habitat, scale insects cause some distress, but the larva of a local butterfly inflicts the most damage. Plants often have their leaves completely stripped of leaflets by infestations of these caterpillars. They not only attack the soft new leaves, but the hard old leaves as well, and the chewing sounds can be heard a dozen feet (3.5 m) away! Herds of goats feed in the cycad's distributional area, and they are also known to cause a great deal of damage to the dioons.

In cultivation, *Dioon califanoi* will grow reasonably fast if given a well-drained soil mix, fertilizer during the warm months, and plenty of sun. It is a hardy species, withstanding several degrees of frost without leaf damage. It is a good plant for desert gardens but will grow equally well in wetter situations if given good drainage and sufficient sunlight.

The conservation status of *Dioon califanoi* is not secure. In 1975 a road was constructed through the main population of *D. califanoi,* destroying many plants. After its completion, an area 6 m (20 ft) wide was cleared on both sides of the road, destroying many more specimens. Once the road was completed, it allowed access to the area and land clearance for agriculture began. Only a small portion of the original population remains and it is under extreme pressure as a result of continued, uncontrolled land clearance. For these reasons, *D. califanoi* is considered at risk of extinction in the wild.

Dioon caputoi De Luca, Sabato & Vázquez-Torres 1980a

PLATES 186, 187

Dioon caputoi, named in honor of Giuseppe Caputo (b. 1926), professor of botany and director of the Institute of Botany, University of Naples, Italy, is called *palma real.* **Stems** arborescent, erect, to 1 m (3.3 ft) tall or more, 20–25 cm (8–10 in) in diameter. Cataphylls woolly, 12–14 cm (4.7–5.5 in) long, 2 cm (0.8 in) wide at the base. **Leaves** numerous, stiff, smooth, 75–90 cm (30–36 in) long or more, about 15 cm (6 in) wide, flat. Petiole 12–15 cm (4.7–6 in) long, 5–7 mm (0.2–0.3 in) in diameter. Leaflets in 50–70 pairs, linear lanceolate, gradually acuminate to a terminal spine, basal leaflets reduced in length toward the base but not to spines, median leaflets 6–10 cm (2.4–4 in) long, 4–5 mm (0.2 in) wide, angled forward about 45°, and spaced 5–7 mm (0.2–0.3 in) apart, margins revolute, the upper margin entire or with one spine, rarely two, 2–3 mm long, the lower margin generally entire. **Female cones** solitary, ovoid cylindrical, 30–40 cm (12–16 in) long, 20–25 cm (8–10 in) in diameter. Peduncle not visible, the cone appearing sessile. Sporophyll face triangular, 12–14 cm (4.7–5.5 in) high, 4.5–5 cm (1.8–2 in) wide, densely tomentose. Sarcotesta yellow when ripe. Sclerotesta subglobose, 35–40 mm (1.4–1.6 in) long, 27–35 mm (1.1–1.4 in) in diameter, more or less smooth except for some occasional indistinct longitudinal grooves. Chalaza with a pit 1–3 mm in diameter. **Male cones** solitary, erect, elongate cylindrical, 30–40 cm (12–16 in) long, 9–10 cm (3.5–4 in) in diameter, densely tomentose. Peduncle short, cone appearing sessile. Sporophyll face triangular, about 1.5 cm (0.6 in) high and wide, tomentose. Sporangia separated into two lobes and covering the entire underside of the sporophyll. **Habitat:** Open stunted oak forest and thornbush in association with cacti and *Agave* at an elevation of about 2000 m (6500 ft). Rainfall averages 25–50 cm (10–20 in) annually, falling mainly in summer. Summer temperatures average 20–30°C (68–86°F), with winter lows sometimes falling below 0°C (32°F). **Distribution:** Mexico, Puebla state, near the town of San Luis Atolotitlán, only two small colonies known, comprising roughly 100 individuals.

In 1907, Carl Albert Purpus, a botanist working in Mexico, collected material of a *Dioon* near San Luis Tultitlanapa (now San Luis Atolotitlán) that he attributed to the soon to be published *D. purpusii.* He returned to the same area in 1908 and collected additional specimens. In 1909 Joseph Nelson Rose described *D. purpusii* from specimens collected in Tomellin Canyon, Oaxaca, including the specimens collected by Purpus. Julius Schuster, writing of *D. purpusii* in 1932, not only referred to the Purpus collections but used one of his photographs, taken of a plant in habitat, to illustrate it. It was not until the late 1970s that a group of Italian botanists recognized the Purpus collections as distinct.

During the 1990s some seed was made available to collectors, helping to establish *Dioon caputoi* in cultivation. Seedlings grow slowly but are very hardy. Mature plants have proved to be somewhat difficult to reestablish and maintain. *Dioon caputoi* is not a particularly handsome cycad, but rather an interesting one because of its very narrow, widely spaced leaflets.

The interesting and rare *Dioon caputoi* inhabits a very inhospitable area several hours' walk from San Luis Atolotitlán. The plants are small for a *Dioon* and because of their widely spaced leaflets are extremely difficult to detect in the thick thornbush and dwarf oaks under which they grow. Without a guide, one could search for months for the plant without a hope of finding it. My guide had grown up in the district and been a goatherd there for many years. He said that to his knowledge there were no other cycads for many miles in all directions. *Dioon caputoi* apparently sets viable seed regularly, but because the habitat is so dry, few of them ever survive. Because it occurs in a remote area and grows on poor land not suitable for agriculture, there does not seem to be any immediate threat to the populations unless from collectors. This would seem unlikely because of the difficulty of access to its habitat. Yet, seedling regeneration in habitat is sparse and I would consider *D. caputoi* as extremely endangered.

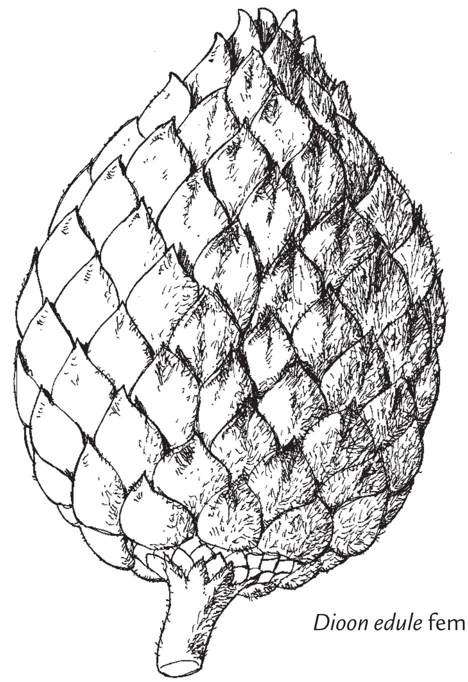
Dioon edule Lindley 1843, as *"Dion" edule*

PLATE 188

Zamia macleni Miquel 1844b
Platyzamia rigida Zuccarini 1845
Dioon imbricatum Miquel 1848
Dioon strobilaceum Lemaire 1863
Dioon edule var. *lanuginosum* Wittmack 1899

Dioon edule, the epithet derived from *edulis,* Latin for edible, referring to the use of the seeds as food, is called *palma de dolores, chamal,* and *palmita.* Two varieties of *D. edule* are recognized: *edule* (described here) and *angustifolium.* **Stems** arborescent, erect or decumbent, to 3 m (10 ft) tall or more, 20–40 cm (8–16 in) in diameter, covered with an armor of persistent leaf bases and cataphylls. **Leaves** numerous, stiff, straight, green to slightly glaucous, 0.9–1.4 m (2.9–4.6 ft) long, 17.5–20 cm (7–8 in) wide, flat or lightly keeled, emergent leaves either green or yellowish brown, slightly white hairy but soon glabrous. Petiole semiterete, 3–13 cm (1.2–5.1 in) long, 8–13 mm (0.3–0.5 in) in diameter at the lowest leaflets, unarmed. Leaflets in 80–130 pairs, linear lanceolate, gradually acuminate, separated or overlapping toward the leaf apex, usually inserted at right angles to the rachis, becoming shorter toward the apex and base but not reduced to prickles on the petiole, median leaflets 6–12 cm (2.4–4.7 in) long, 5–9 mm (0.2–0.4 in) wide, margin slightly revolute and without spines except in seedlings or young plants. **Female cones** solitary, erect at first, then leaning, ovoid, 25–29 cm (10–11 in) long, 19–24 cm (7.5–9.4 in) in diameter, densely tomentose except for one or two rows of glabrous sporophylls just above the base. Peduncle 4–5 cm (1.6–2 in) long, 2.5 cm (1 in) in diameter, buried among the cataphylls and the cone often appearing sessile. Sporophylls 65–72 mm (2.6–2.8 in) long. Sporophyll face triangular, 9.8–11 cm (3.9–4.3 in) high, 4.5–5.5 cm (1.8–2.2 in) wide, densely tomentose. Sarcotesta yellow when ripe. Sclerotesta ovoid to globose, 24–30 mm (0.9–1.2 in) long, 19–22 mm (0.8–0.9 in) in diameter, more or less smooth but with 12–16 indistinct longitudinal grooves. **Male cones** solitary, cylindrical, 17.5–20 cm (7–8 in) long, 6–7.5 cm (2.4–3 in) in diameter, densely white or brownish gray tomentose. Peduncle 3–3.5 cm (1.2–1.4 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, the cone often appearing sessile. Sporophylls with pointed or ovate tips and angled upward. Sporophyll face triangular, 12–15 mm (0.5–0.6 in) wide, 10 mm (0.4 in) high, densely tomentose. Sporangia in a single patch extending up the sides of the sporophyll. **Habitat:** Generally in areas transitional between tropical deciduous forest and oak woodland, in rocky habitats or on steep cliffs, at elevations of 500–1500 m (1600–4900 ft). Rainfall averages 1000–1500 mm (39–59 in) annually, falling mainly in summer. **Distribution:** Mexico, in Hidalgo, Querétaro, San Louis Potosí, southern Tamaulipas, and Veracruz states, along the eastern slopes of the Sierra Madre Oriental.

The range of *Dioon* along the eastern coast of Mexico is broken into numerous populations, each showing variation in one respect or another. These populations show great variability in leaf length and width, angle of insertion of the leaflets, leaflet width, leaflet margins, elevational range, and so on. The problem facing the taxonomist is that most of these populations have been isolated from each other for so long that they have evolved different characteristics and adaptations to differing habitats. That these populations are relatively distinct can be seen by comparing their seedling leaves. In most cases,



Dioon edule female cone

even as a seedling, these various dioons can be distinguished. A taxonomic treatment that divides this complex into two varieties is the easiest way to handle the nomenclature but in my opinion is too simplistic. Any dioons from the states of Nuevo León and Tamaulipas are now considered *D. edule* var. *angustifolium,* the remainder as *D. edule* var. *edule.* I have no doubt that when there has been sufficient time to study these varying populations more critically, additional species will be named. Variations worthy of mention include the following, arranged by state, north to south:

Valles form (Plates 191–193), San Luis Potosí, elevation about 150 m (500 ft). Stems seldom reaching 30 cm (12 in) tall, producing numerous offsets tightly crowded around the parent. Leaves 55–57.5 cm (22–23 in) long, 10 cm (4 in) wide. Female cones about 14 cm (5.5 in) long, 9 cm (3.6 in) in diameter, densely tomentose. Male cones 5.5–8 cm (2.2–3.2 in) long, 3–4 cm (1.2–1.6 in) in diameter, almost glabrous.

Río Verde form (Plates 194, 195), San Luis Potosí, elevations of 230–300 m (750–980 ft). Stems 1.5–1.8 m (4.9–5.9 ft) tall, 22.5 cm (8.9 in) in diameter. Leaves slightly arching, about 1.2 m (3.9 ft) long and 16.5 cm (6.5 in) wide, flat, leaves and leaflets intense blue-gray when new. Female cones small, sporophylls long, narrow. Seeds small. Sarcotesta distinctively light yellow.

Querétaro form (Plates 196, 197), Querétaro, elevation about 1230 m (4000 ft). Stems to about 1.2 m (3.9 ft) tall. Leaves slightly twisted, slightly curved inward, about 84 cm (33 in) long and 21 cm (8.3 in) wide, flat, emergent leaves an intense blue-gray. Leaflets with strongly revolute margins. Female cones with short sporophylls, blunt apexes.

Jacala form (Plates 198, 199), Hidalgo, elevation about 1400 m (4500 ft). Stems to 3 m (10 ft) long, often decumbent. Leaves stiff, glossy bright green, about 1.2 m (3.9 ft) long and 22.5 cm (8.9 in) wide, flat. Rachis distinctly yellowish. Leaflets with strongly revolute margins. Male cones somewhat glabrous, only the sporophyll apex with a patch of light brown tomentum.

Palma Sola form (Plates 200, 201), Veracruz, from sea level to about 200 m (650 ft). Stems medium sized. Leaves numerous, 0.9–1 m (2.9–3.3 ft) long, 16.5 cm (6.5 in) wide, unlike variety *edule* the leaves keeled, with crowded, overlapping leaflets in the apical third to half of the leaf. Sarcotesta uniquely orange-yellow.

All these variations are easily grown and respond well to cultivation. Some, like *Dioon edule* var. *angustifolium,* are dwarfs and have a very slow growth rate. Most of the others have a relatively rapid growth rate if given good soil and sufficient water and fertilizer. The seeds need about 6–8 months to form the embryo after being shed from the cone. At that point germination is rapid, but the formation of the first leaf varies considerably, depending on the variety being grown. Seed of *D. edule* stores well and will keep two to three seasons without noticeable loss of viability. As the name *edule* implies, seed of this cycad has been used extensively as a food item. It is seldom used today, "civilized" food being easily and cheaply obtained. No doubt there are some areas where seed is still eaten as a famine food, but this is now rare.

Dioon edule must be considered as not threatened because of the large number of plants in existence and their wide distribution. Yet, inroads have been made into this cycad's range, and untold thousands have been removed as ornamentals, mainly to markets in the United States, while others have been eliminated through land clearance. Another threat is the practice of decapitating mature plants so that the heads with leaves attached can be sold in the markets to be used as decorations. This practice has all but eliminated the production of seed in some areas and unless stopped will eventually have devastating effects on many populations. It is hoped that strict conservation laws can be passed and enforced by the Mexican government before irreparable damage is done.

Dioon edule var. *angustifolium* (Miquel) De Luca, Sabato & Vázquez-Torres 1982

PLATES 189, 190

Dioon angustifolium Miquel 1848

Dioon aculeatum Lemaire 1855, the name appearing without description in Van Houtte 1846

The varietal epithet of *Dioon edule* var. *angustifolium* is derived from *angusti-,* Latin for narrow, and *folium,* leaf, referring to the narrow leaflets. STEMS as in variety *edule* but generally shorter. LEAVES mostly as in variety *edule,* differing primarily in the narrower leaflets, 6–11 cm (2.4–4.3 in) long, rarely as long as 16 cm (6.3 in), 4–6 mm (0.2 in) wide, angled forward, generally glaucous when young. FEMALE CONES as in variety *edule* except the sclerotesta irregularly ovoid to subglobose, generally smaller, 19–25 mm (0.8–1 in) long, 19–20 mm (0.7–0.8 in) in diameter. MALE CONES erect until the pollen is shed, about 20 cm (8 in) long and 7.5 cm (3 in) in diameter, densely brown-gray tomentose. HABITAT: As in variety *edule.* DISTRIBUTION: Mexico, Nuevo León and Tamaulipas states.

Dioon holmgrenii De Luca, Sabato & Vázquez-Torres 1981b

PLATES 202, 203

Dioon holmgrenii, named in honor of Noel Herman Holmgren (b. 1937), taxonomist and curator at the New York Botanical Garden, is called *palma del sol,* and *plumilla.* **Stems** arborescent, cylindrical, erect or leaning, to about 6 m (20 ft) tall, 17.5–40 cm (7–16 in) in diameter. Cataphylls tomentose, 7–9 cm (2.8–3.5 in) long, 2 cm (0.8 in) wide. **Leaves** numerous, upright, then spreading, leathery, smooth, 1.3–1.5 m (4.3–4.9 ft) long, 20–27 cm (8–11 in) wide, flat, emergent leaves densely tomentose, the tomentum persisting as long as a year. Petiole semiterete, 11–15 cm (4.3–6 in) long, 1–1.2 cm (0.4–0.5 in) in diameter. Rachis semiterete, straight or sometimes slightly twisted near its apex. Leaflets in 100–130 pairs, angled forward about 60°, median leaflets 10–12 cm (4–4.7 in) long, 7–9 mm (0.3–0.4 in) wide, with about 15 veins, the leaflets spaced about 4 mm apart, gradually reduced in length toward the base but not to prickles, margins slightly revolute, the upper margin generally with two to four spines, the lower smooth or with one spine about 2 mm long. **Female cones** solitary, sometimes a previous year's cone present, giving the appearance of two cones being produced in a single season, ovoid to ovoid cylindrical, 30–50 cm (12–20 in) long, 20–30 cm (8–12 in) in diameter, densely brownish gray tomentose. Peduncle short, cone appearing sessile. Sporophylls 5–6 cm (2–2.4 in) long. Sporophyll face triangular ovate to long triangular, 9–12 cm (3.5–4.7 in) high, 4–5 cm (1.6–2 in) wide, densely light brown tomentose. Sarcotesta bright yellow when ripe. Sclerotesta subglobose and 2.5–3 cm (1–1.2 in) in diameter or ovoid cylindrical and 3.5–4 cm (1.4–1.6 in) long, 2.5 cm (1 in) in diameter, the surface smooth except for a few shallow and indistinct longitudinal grooves. Chalaza with pit 2–6 mm (to 0.2 in) in diameter. **Male cones** solitary, erect, elongate cylindrical, 30–40 cm (12–16 in) long, 6–7.5 cm (2.4–3 in) in diameter, densely light brown tomentose. Peduncle 1–2 cm (0.4–0.8 in) long, the cone usually appearing sessile. Sporophylls about 33 mm (1.3 in) long. Sporophyll face somewhat triangular, 13–15 mm (0.5–0.6 in) high, 12–19 mm (0.5–0.7 in) wide, densely tomentose. Sporangia in a single patch covering the entire underside of the sporophyll and forming two lobes on its forward edge, or in two patches narrowly separated by a sterile ridge. **Habitat:** Moist oak or pine-oak forest intruding into tropical deciduous forest, usually with a northeastern exposure and at elevations of 650–850 m (2100–2800 ft). Rainfall averages 1000–1500 mm (60–80 in) annually, falling mainly in summer. Temperatures average 20–30°C (68–86°F) in summer and 10–20°C (50–68°F) in winter. **Distribution:** Mexico, Oaxaca state, to the west of San Gabriel Mixtepec where it appears to be very restricted.

Dioon holmgrenii is the only species of the genus found along the Pacific slope of the Sierra Madre del Sur. Paolo De Luca, Sergio Sabato, and Mario Vázquez-Torres stated that all other *Dioon* species are located well to the east in the Sierra Norte de Oaxaca, also known as the Sierra Mixes. I am aware of three other colonies of *Dioon* that appear to be more closely related to *D. merolae* that occur in the vicinity of San Pedro Juchatengo, El Camarón, and Presa Benito Juárez, Oaxaca. Additional study will be necessary to understand the relationships of these plants fully, but they are definitely neither *D. holmgrenii* nor *D. merolae.*

In cultivation, *Dioon holmgrenii* does best in a warm temperate to subtropical climate. It has a reasonably rapid rate of growth and is generally trouble-free if provided with good drainage and regular applications of fertilizer. It does well as a pot plant but grows more rapidly when planted in the ground. Best growth is achieved when it is planted in full sun. When grown in shady situations, the growth rate is slower and plants often suffer from insect infestations. *Dioon holmgrenii* is relatively hardy and can withstand several degrees of frost without leaf damage.

In the past, the habitat of *Dioon holmgrenii* was quite remarkable as plants were found growing only in an oak and pine forest intrusion into tropical deciduous forest. I had never observed this cycad growing outside the oak-pine forest. In 1990 I returned to the habitat to find that all of the oaks and most of the pines had been cut down. I am pleased to report that the cycads appear to be in better condition now than when they were growing under the oaks. The exposure to more daylight has caused an increase in the reproductive activity of the colony, and the production of cones is more frequent. But the conservation status of *D. holmgrenii* is not secure. Only two small colonies of this interesting species are known to exist. A large part of the habitat has been cleared of all trees for the planting of corn, and grass for feeding domestic animals, and in more recent years goats and cattle have had access to the habitat, almost completely halting seedling regeneration. Taking all factors into consideration, *D. holmgrenii* must be considered endangered.

Dioon mejiae Standley & L. O. Williams 1950

PLATES 204–206

Dioon edule var. *latipinna* Thiselton-Dyer 1883b

Dioon pectinatum Masters 1893, without description

Dioon mejiae, named in honor of Isidoro Mejia H. of Danli, Honduras, from whose garden the type specimen of this cycad was collected, is called *teosinte,* the same name given to the grass *Zea mays* subsp. *mexicana.* **Stems** arborescent, erect, to 7.3 m (24 ft) tall, 17–36 cm (6.7–14 in) in diameter. **Leaves** numerous, stiff, dull green, spreading and slightly arching, 1–2 m (3.3–6.6 ft) long, 34 cm (13 in) wide, flat, emergent leaves densely light brown tomentose, then glabrous with age. Petiole lacking as the reduced leaflets continue to the base of the leaf. Rachis semiterete. Leaflets in 75–100 pairs or more, straight or slightly falcate, gradually acuminate from the attachment toward the apex, medium green, median leaflets 15–17 cm (6–6.7 in) long, 1.5 cm (0.6 in) wide, gradually reduced in length from midleaf to apex and base, the lowest reduced to prickles, margins revolute and entire in mature leaves, moderately armed with marginal spines in seedlings and submature plants. **Female cones** solitary, generally leaning or pendent when mature, ovoid, 30–46 cm (12–18 in) long, 25–35 cm (10–14 in) in diameter, densely tan tomentose, apex abruptly acuminate. Peduncle 6–7.5 cm (2.4–3 in) long, densely tan tomentose. Sporophyll face deltoid ovate, 8–12 cm (3.2–4.7 in) high, 7–9 cm (2.8–3.5 in) wide, densely tomentose, apex often slightly deflexed in mature cones. Sarcotesta yellow when ripe. Sclerotesta irregularly ovoid to subglobose, 4.5–5.5 cm (1.8–2.2 in) long, 3–3.5 cm (1.2–1.4 in) in diameter, the surface heavily and irregularly fissured. Chalaza extended into a very irregular growth 4–8 mm (to 0.3 in) long, 11–18 mm (0.4–0.7 in) in diameter, containing an irregular pit at its apex. **Male cones** solitary, erect, cylindrical, 25–45 cm (10–18 in) tall, 9.5–10.5 cm (3.7–4.1 in) in diameter, densely tan tomentose. Peduncle 7.5–8 cm (3–3.2 in) long, 3–4.5 cm (1.2–1.8 in) in diameter, densely tan tomentose. Sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 10–13 mm (0.4–0.5 in) high, 17–20 mm (0.7–0.8 in) wide. Sporangia in a single patch with a distinct longitudinal fold separating the two halves. **Habitat:** Steep slopes and canyons in semideciduous tropical rain forest, generally at elevations of 265–500 m (870–1600 ft), in soil that is generally decomposed granite and rich in humus. The climate is subtropical, and rain falls generally in summer. **Distribution:** Honduras, Olancho department, near Olanchito and Ocote in the catchment area of the Río Aguán, the local Indians informing me that it extends south and west from there into adjacent Nicaragua.

Dioon mejiae was described in 1950 by Paul C. Standley and Louis O. Williams, both prominent students of the Central American flora. The description was remarkable in that it was made without knowledge or specimens of either female or male cones. The authors felt it must be a distinct species as it was isolated by hundreds of miles from the other species of the genus. When I first read the description, I felt there was a strong possibility it was nothing more than *D. spinulosum* that might have been carried down the Indian trade routes from southern Mexico. This theory was soon shattered when I went to Honduras and observed firsthand *D. mejiae* and its unique seeds.

In Honduras as in Mexico, the seed of *Dioon* has been used as food, usually in times of famine. I found it was still being used in Honduras when I visited there in 1976. The large, strangely shaped, deeply fissured seeds of *D. mejiae* are still used for food by the local Indians who shell seeds, then grind, boil, and wash the kernels, from which they make flour that is used for a kind of tortilla said to have a fine flavor. I was unable to learn from the Indians how long the cone takes to mature but I would guess it might be well over a year, as in some of Mexico's dioons. The leaves of this cycad are also in demand for decorating altars and for funeral wreaths and are sold locally at a relatively high price.

In cultivation, *Dioon mejiae* is a beautiful and decorative cycad, somewhat similar to *D. spinulosum* in outward appearance. Adult plants of *D. mejiae* can be separated from *D. spinulosum* by their relatively stiff, straight, flat leaves, and leaflets without marginal spines. Seedlings of *D. mejiae* have basal leaflets reduced to spines whereas *D. spinulosum* has a long, smooth petiole and lower leaflets not reduced to spines. The seeds are also easily separated as those of *D. mejiae* have a rough, deeply fissured surface and a prominent extension at the chalaza whereas those of *D. spinulosum* are smooth and the chalaza has only a small pit. In more recent years, seed of *D. mejiae* has become more readily available to growers, and numerous seedlings have been produced. *Dioon mejiae* is best suited to tropical and subtropical climates but also grows well under temperate conditions. Its ease in horticulture, adaptability to both sun and shade, and some cold tolerance make this cycad an exceptional landscape plant. Plants in cultivation produce more and larger leaves than their wild counterparts and are reasonably fast growing. *Dioon mejiae* will develop into a sizable plant in a relatively short time, especially in more tropical climates.

The original description of *Dioon mejiae* was based on a garden plant, and Standley and Williams stated that it "was found wild in a single canyon of Olanchito." This is definitely not the case as I have seen many hundreds of specimens in the hills on both sides of the Río Aguán below Olanchito. The local Indians informed me that this cycad's range extends west into Nicaragua. Because of the large numbers of plants in habitat, and its extensive range, *D. mejiae* may be considered not threatened.

Dioon merolae De Luca, Sabato & Vázquez-Torres 1981a

PLATE 207, 208

Dioon merolae, named in honor of Aldo Merola (1924–1980), director of the Botanical Garden, Naples, Italy, in recognition of his knowledge of and conservation of cycads, is called *espadaña.* STEMS arborescent, usually erect, to 3 m (10 ft) tall, sometimes reclining, rarely as long as 8 m (26 ft), 20–40 cm (8–16 in) in diameter, very old plants often suckering and forming large clumps. LEAVES numerous, rigid and leathery, upright, dark green to glaucous green, 0.8–1 m (2.7–3.3 ft) long or more, 13–15 cm (5.1–6 in) wide, flat, emergent leaves densely tomentose but soon glabrous. Petiole semiterete, 7–15 cm (2.8–5.9 in) long, 1–1.2 cm (0.4–0.5 in) in diameter. Rachis semiterete, sometimes slightly twisted. Leaflets in 120 pairs or more, linear lanceolate, sharply pointed, leathery, angled forward in the upper rachis and overlapping, the tips often curved toward the leaf apex, median leaflets 7–9 cm (2.8–3.5 in) long, 1–1.2 cm (0.4–0.5 in) wide, with about 20 veins, margins revolute, the upper margin in adult plants with none to four spines, the lower with none to two, the lower leaflets entire. FEMALE CONES solitary, erect, ovoid, 40–45 cm (16–18 in) long, 20–25 cm (8–10 in) in diameter, densely gray tomentose except for the two bottom rows of completely glabrous sporophylls. Peduncle short, cone appearing sessile. Sporophyll face long triangular, 10.5–11.5 cm (4.1–4.5 in) high, 7.5–8 cm (3–3.2 in) wide, densely tomentose. Sarcotesta yellow when ripe. Sclerotesta 33–41 mm (1.3–1.6 in) long, 24–32 mm (0.9–1.3 in) in diameter, smooth except for a few shallow and indistinct longitudinal grooves. Chalaza with pit 5–8 mm (0.2–0.3 in) in diameter. MALE CONES solitary, elongate cylindrical, 20–40 cm (8–16 in) long, 8–10 cm (3.2–4 in) in diameter, densely light brown tomentose. Peduncle short, cone appearing sessile. Sporophyll face triangular, 10–14 mm (0.4–0.6 in) high, 15–20 mm (0.6–0.8 in) wide, densely tomentose. Sporangia in a double patch that joins together in the basal half and covers the entire undersurface of the sporophyll, including the edges. HABITAT: Open pine-oak forest or tropical semideciduous forests, at elevations of 650–1200 m (2100–3900 ft). DISTRIBUTION: Mexico, Chiapas state, known from three widely scattered locations in the districts of Cintalapa and Villa Flores; Oaxaca state, in the Sierra de Juárez and the Sierra Madre del Sur.

Dioon merolae was recognized as a new species for many years before it was validly described in 1981. In the past it has been known as *D. "dohenyi," D. "penoi,"* and *D. "tomentosum,"* names not validly published. In the 1981 description, the range of *D. merolae* was said to be restricted to Chiapas, Mexico. In 1997, Jeffrey Chemnick and Timothy Gregory, investigating dioons in southern Oaxaca, discovered three separate populations of *D. merolae* some 150 km (93 miles) to the west of the Chiapas plants.

Dioon merolae is a handsome cycad with leaves of medium proportions, making it a fine conservatory or landscape plant for warm temperate to tropical climates. Relatively fast growing from seed, it is easy to grow when given well-drained soil and frequent applications of fertilizer. It is somewhat cold sensitive, and leaf damage may occur at a few degrees below freezing, the amount of damage usually depending on how long the freezing temperature is maintained.

In its natural habitat, *Dioon merolae* is known to grow to large proportions, often producing upright stems to 3 m (10 ft) tall or decumbent trunks to 8 m (26 ft) long. Older specimens may produce numerous offsets, eventually forming a large clump. New foliage is covered with a fine, dense tomentum that persists for several months, particularly on the underside of the leaves.

Dioon merolae must be considered threatened. There are several locations where this cycad is reasonably common and seed production good, but seedling regeneration is poor. This is no doubt the result of the harsh, desertlike climatic conditions the plants must endure. There is also the problem of an ever increasing demand for this cycad as an item of decoration. The top portion of the stem, with leaves attached, is cut off and sold in local markets as a table decoration. The remaining mutilated plants are then incapable of reproduction for many years. We must hope that this practice can be stopped before complete destruction of the remaining colonies takes place.

Dioon purpusii Rose 1909

PLATES 209, 210

Dioon purpusii, named in honor of Carl Anton Purpus (1853–1914), one of the leading botanical researchers in Mexico at the turn of the twentieth century, is called *palma real.* **Stems** arborescent, erect but in older plants sometimes reclining as a result of the weight of the trunk and crown, solitary or suckering from the base in older specimens, 1–5 m (3.3–16 ft) long, 25–40 cm (10–16 in) in diameter. Cataphylls 7–8 cm (2.8–3.2 in) long, 1.5–2 cm (0.6–0.8 in) wide, densely covered with persistent tomentum. **Leaves** numerous, rigid, upright, in mature plants sometimes curved slightly backward and downward toward the apex, 0.8–1.6 m (2.6–5.2 ft) long, 16 cm (6.4 in) wide, flat or slightly keeled in immature plants, emergent leaves densely tomentose, the tomentum persistent on the petiole, rachis, and underside of the leaflets. Petiole 5–20 cm (2–7.9 in) long, somewhat four-angled, the swollen base 2–3 cm (0.8–1.2 in) wide. Leaflets in 75–130 pairs, stiff, pungent, angled forward, 7–11.5 cm (2.8–4.5 in) long, 8–10 mm (0.3–0.4 in) wide, persistently tomentose, inserted into the rachis at an angle with the leading edge higher, closely set in the upper portion of the leaf and overlapping, in the lower portion spaced 1.5–3 cm (0.6–1.2 in) apart, margins entire or with small spines, sometimes with two or three spinelike teeth 2–3 mm long on the upper margin, rarely with one or two spinelike teeth on the lower. **Female cones** solitary, at first upright, later somewhat angled to the side, ovoid, 44–52.5 cm (17–21 in) long, 20–25 cm (8–10 in) in diameter near the base. Peduncle short, cone appearing sessile. Sporophyll face long triangular, 10–18.5 cm (4–7.3 in) high, 5–9.5 cm (2–3.7 in) wide at the base, densely woolly. Sarcotesta yellow when ripe. Sclerotesta subglobose, 30–40 mm (1.2–1.6 in) long, 29–30 mm (1.1–1.2 in) in diameter, smooth. Chalaza with pit 4–5 mm (0.2 in) in diameter. **Male cones** solitary, erect until the pollen is shed, 20–36 cm (8–14 in) long, 7–13 cm (2.8–5.1 in) in diameter. Peduncle short, 2–5 cm (0.8–2 in) long, 2.5–3 cm (1–1.2 in) in diameter, the cone usually appearing sessile. Sporophylls 47–50 mm (1.8–2 in) long. Sporophyll face triangular, 15–22 mm (0.6–0.9 in) high and wide, gray-green, apex densely light brown tomentose, curved slightly backward and downward. Sporangia in two adjacent patches separated by a sterile zone 2 mm wide. **Habitat:** Dry, exposed situations in tropical deciduous forest and usually shaded by trees and shrubs, generally on steep rocky hillsides in deep canyons in association with cacti, *Agave,* and *Beaucarnea,* at elevations of 1000–1500 m (3300–4900 ft). Rainfall averages 500–1000 mm (20–40 in) annually, falling mainly in summer. Temperatures average 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Mexico, Oaxaca state, Tomellin Canyon near the villages of Santa Catarina and Tomellin.

Dioon purpusii was first botanically collected in 1901 by C. Gonzatti and V. Gonzáles who identified it as *D. edule.* In 1908 it was collected again by Joseph Nelson Rose, who recognized it as undescribed and described it in 1909. The description was very concise and not provided with illustrations, making identification of *D. purpusii* very difficult. At the time, *D. purpusii* was the only species of the *D. edule* complex known to have marginal spines on mature leaflets. This led to a great deal of confusion, and subsequently, other populations of *Dioon* were incorrectly identified as *D. purpusii* simply because they had marginal spines. Until 1980, commercial plant dealers sold any *Dioon* with marginal spines on its leaflets as *D. purpusii.* Included in this group are *D. holmgrenii, D. merolae, D. tomasellii,* and the dioons from near San Pedro Juchatengo and El Camarón, Oaxaca, Mexico. Thus most, if not all, dioons obtained as *D. purpusii* before 1975 are probably not that species. Many of these dioons found their way into private and public collections, where many remain misidentified.

The only species that might be confused with *Dioon purpusii* is *D. califanoi,* which occurs farther north in Tomellin Canyon, Oaxaca. The following differences distinguish the two species. In *D. purpusii,* leaves are straight and upright, dull green, and flat or only slightly keeled, with leaflets 7–11.5 cm (2.8–4.5 in) long. In *D. califanoi,* leaves are arching and spreading, glaucous, and strongly keeled, with leaflets only 6–7 cm (2.4–2.8 in) long.

Dioon purpusii is a majestic cycad, occurring in large numbers in colonies scattered between Tomellin and Santa Catarina in Tomellin Canyon. The area is quite remote, and few botanists have visited *Dioon purpusii* in its habitat since its discovery in 1901. Because of its inaccessibility, few specimens have ever been brought into cultivation.

In cultivation, *Dioon purpusii* grows well and holds a large number of leaves in good condition. The upright leaves make it a very decorative garden plant, and if it were commonly available there is no doubt it would figure prominently in landscape projects. *Dioon purpusii* can withstand several degrees of frost without apparent damage and is quite drought and heat resistant. It grows well from seed and can be considered moderate in growth rate. Insect pests are not a problem except for an occasional infestation of scale insects. In its habitat, *D. purpusii* may have its foliage damaged by grasshoppers or the larvae of a cycad butterfly, which can sometimes completely defoliate the plant. Usually, just the soft, emerging leaves are eaten, but I have also witnessed the butterfly larvae consuming the hard, mature leaves, and the sound of their chewing can be heard several feet away. Female cones are often attacked by rodents that eat the seed sarcotesta, then carry off the seeds to eat them later. The seeds are hidden in rock crevices, often some distance from the female plant, where many of them ultimately germinate, thereby assisting in their dispersal. Female cones of *D. purpusii* take as long as 15 months to mature.

Seedling regeneration in habitat is good and the remote location of the colonies has all but prevented commercial collection. The local inhabitants do not molest the cycads except for the collection of leaves, which are used as decoration on holidays such as Palm Sunday. For these reasons, *Dioon purpusii* is not considered threatened.

Dioon rzedowskii De Luca, Moretti, Sabato & Vázquez-Torres 1980b

PLATES 211, 212

Dioon rzedowskii, named in honor of Jerzy Rzedowski (b. 1926), a prominent taxonomist and researcher of the Mexican flora, is called *tush-kju* in Mazatec. **Stems** arborescent, unbranched, erect or reclining in old age, to 5 m (16 ft) tall or more, 25–40 cm (10–16 in) in diameter. Cataphylls densely tomentose, 16–18 cm (6.3–7.1 in) long, 2 cm (0.8 in) broad at the base. **Leaves** numerous, upright, arching, glossy green, leathery, 1.6 m (5.2 ft) long or more, 28–38 cm (11–15 in) wide, flat, emergent leaves densely tomentose, then glabrous with age. Petiole semiterete, 10–15 cm (4–6 in) long, 3–4 cm (1.2–1.6 in) wide at the base. Rachis semiterete and straight. Leaflets in 80 pairs or more, subopposite, elongate lanceolate, unequally drawn out, reduced in length toward the base but not to spines, apex pungent, median leaflets 14–19 cm (5.5–7.5 in) long, 18–21 mm (0.7–0.8 in) wide, with 30–35 veins, margins slightly revolute, entire in mature plants, in juveniles both margins armed with numerous spines. **Female cones** solitary, pendent below the leaves, ovoid cylindrical, 60–75 cm (24–30 in) long, 20–25 cm (8–10 in) in diameter, densely tomentose, apex blunt. Peduncle 17.5–20 cm (7–8 in) long, 5 cm (2 in) in diameter, densely tomentose. Sporophyll face deltoid ovate, 9–10 cm (3.5–4 in) high, 5 cm (2 in) wide at the base, densely tomentose, in mature cones often deflexed at the apex. Sarcotesta yellow when ripe. Sclerotesta ovoid cylindrical, 5–6 cm (2–2.4 in) long, 3 cm (1.2 in) in diameter, medium brown, smooth. Chalaza with prominent pit, shallow, well defined, 6.3–12.5 mm (0.25–0.5 in) in diameter. **Male cones** solitary, cylindrical, erect, 30–50 cm (12–20 in) long, 8–12.5 cm (3.2–4.9 in) in diameter. Peduncle 45–50 mm (1.8–2 in) long, 38 mm (1.5 in) in diameter, densely tomentose. Sporophylls deltoid, 3–3.5 cm (1.2–1.4 in) long, densely tomentose. Sporophyll face 15–18 mm (0.6–0.7 in) high and wide. Sporangia in a single patch covering the underside of the sporophyll. **Habitat:** Steep slopes and limestone cliffs in open tropical deciduous forest at elevations of 650–850 m (2100–2800 ft), associated with *Beaucarnea, Plumeria alba,* and *Pseudobombax ellipticum.* Rainfall averages 1500–2000 mm (59–79 in) annually, falling mostly in summer. Summers are hot, and winters cool but without frost. **Distribution:** Mexico, Oaxaca state, Sierra de Oaxaca, valley of the Río Santo Domingo and near the villages of San Bartolomé Ayautla and San Pedro Teutila.

The closest relatives of *Dioon rzedowskii* are *D. spinulosum* of Mexico and *D. mejiae* of Honduras. *Dioon rzedowskii* and *D. spinulosum* are separated geographically by a very short distance but are restricted to different habitats. *Dioon rzedowskii* inhabits the low mountains of the Sierra de Oaxaca at elevations of 650–850 m (2100–2800 ft) in open moist forest, and *D. spinulosum* inhabits lowlands and the foothills of the Sierra de Oaxaca from sea level to 300 m (980 ft) under the cover of rain forest. Mature specimens may be easily distinguished by a comparison of the leaflets. In *D. rzedowskii* the leaflets are somewhat glossy green with entire margins that taper unequally toward their apex whereas in *D. spinulosum* the leaflets are dull glaucous green and carry spines on both margins. Rarely, some individuals are found that are spine-free. Seedlings, too, are easily distinguished. In *D. rzedowskii* the emergent leaves are densely and persistently tomentose and have glossy green leaflets whereas in *D. spinulosum* the emergent leaves are almost glabrous and have dull glaucous green leaflets.

Dioon rzedowskii in cultivation is a handsome and easily grown cycad that should prove to be an exceptional ornamental. Seedlings have a rapid rate of growth and should develop into mature plants in a few years. In my garden, seedlings have withstood several degrees below freezing without apparent damage. In its habitat, *D. rzedowskii* grows in sunny locations, and for this reason it can be expected to have more sun tolerance than *D. spinulosum. Dioon rzedowskii* is adaptable to a wide range of soil and light conditions and is best suited to subtropical or warm temperate regions. It is rare in collections because of the difficulty in the past of obtaining seed.

Dioon rzedowskii does not appear to be threatened but the colonies are small and its conservation status could change rapidly. Clearing of the steep slopes in its immediate habitat for planting corn has taken place in more recent years, but most of the population grows on steep limestone cliffs and thus has not been in danger. The difficulty of access to its habitat has given this cycad some protection in the past, but a new road has been completed, opening the area to more traffic. Seed production in habitat is good, and seedling regeneration is ample to sustain the colony, barring human interference.

Dioon sonorense (De Luca, Sabato & Vázquez-Torres) Chemnick, Gregory & Salas-Morales 1998a

PLATES 213, 214

Dioon tomasellii var. *sonorense* De Luca, Sabato & Vázquez-Torres 1984

Dioon sonorense, the epithet referring to the Mexican state of Sonora, is called *peine,* comb, in central Sonora, in reference to the leaf, and *palma de la Virgen* in southern Sonora. **Stems** arborescent, erect, attaining a maximum height of about 1.5 m (4.9 ft) but usually with stems no more than 30–90 cm (12–36 in) high, 22–25 cm (8.7–10 in) in diameter, sometimes suckering from the base. **Leaves** numerous, upright, straight but sometimes twisted toward the apex, glaucous, about 1 m (3.3 ft) long, 20–25 cm (8–10 in) wide, emergent leaves lightly gray tomentose, becoming glabrous with age. Petiole terete to subterete, 6–16 cm (2.4–6.3 in) long, 7–10 mm (0.3–0.4 in) in diameter. Leaflets in 70–98 pairs, subopposite, linear lanceolate, straight to slightly falcate, inserted at right angles or slightly angled forward, median leaflets 112–138 mm (4.4–5.4 in) long, 4–6 mm (0.2 in) wide, margins entire or sometimes with one or two small spines on the upper edge near the leaflet apex, rarely with one spine on the lower edge near the apex. **Female cones** solitary, ovoid, 31.5–36 cm (12.4–14 in) long, 20–22.5 cm (8–9 in) in diameter, densely tomentose. Peduncle 50–63 mm (2–2.5 in) long, 38 mm (1.5 in) in diameter, densely tomentose. Sporophylls long triangular with a blunt apex, 5.5–7 cm (2.2–2.8 in) long, densely light brown tomentose. Sporophyll face 85–90 mm (3.3–3.5 in) high, 42–45 mm (1.6–1.8 in) wide. Sarcotesta yellow to orange-yellow when ripe. Sclerotesta 28–32 mm (1.1–1.3 in) long, 23–25 mm (0.9–1 in) in diameter, light tan, smooth. Chalaza with pit 3–4 mm in diameter. **Male cones** solitary, long cylindrical, 25–26.5 cm (10 in) long, 7–8 cm (2.8–3.2 in) in diameter, densely gray tomentose. Peduncle 2–3 cm (0.8–1.2 in) long. Sporophyll face 1 cm (0.4 in) high, 1.5 cm (0.6 in) wide. Sporangia in a single patch. **Habitat:** High desert to oak woodland at elevations of 615–1200 m (2000–3900 ft), usually on steep canyon walls or hillsides in extremely dry conditions. Rainfall is 250–500 mm (10–20 in) annually, falling mainly in summer. **Distribution:** Mexico, Sonora and Sinaloa states, Sierra Madre Occidental.

In 1984, *Dioon tomasellii* and its two varieties, *tomasellii* and *sonorense,* were described by Paolo De Luca, Sergio Sabato, and Mario Vázquez-Torres. I had been uncomfortable with the merging of these two populations into the same species, and I was very pleased when in 1998 Jeffrey Chemnick, Timothy J. Gregory, and Silvia Salas-Morales elevated *D. sonorense* to the rank of species. *Dioon sonorense* is a plant of dry conditions in the Sonoran Desert, its morphology reflecting this with its glaucous leaves and narrow leaflets. Both *D. sonorense* and *D. tomasellii* occur as numerous disjunct populations along Mexico's western coast, but nowhere do the populations overlap or intergrade. The southernmost collection of *D. sonorense* was from the Río Fuerte in northern Sinaloa, and the northernmost station of *D. tomasellii* is from the state of Durango, due east of Culiacán, Sinaloa. The separation between these two locations is more than 240 km (150 miles).

Dioon sonorense, known by the indigenous people as *palma de la Virgen,* has been known to botanists since the early 1900s, but even so it is still uncommon in private collections and botanical gardens. The reason is that there have never been many commercial collectors located in California or Arizona who dealt in cycads. Most cycad imports from Mexico entered at Brownsville, Texas, where a number of Mexican nurserymen and collectors resided. These Texas-based collectors followed the Pan American Highway to Mexico City, where they branched off into the states of Oaxaca, Veracruz, and Chiapas. For them, northwestern Mexico was out of the way and not as rich in species as the Gulf Coast and Isthmus of Tehuantepec. This is not to say that *D. sonorense* has not been exploited. It has been stated that for a number of years there was demand for starch-rich *Dioon* stems, which were harvested, cut up, and fermented to make alcohol. In some areas these plants were almost completely eradicated for this purpose.

Dioon sonorense is easy to grow and comparatively trouble-free. It withstands both full sun and temperatures several degrees below freezing without damage. In southern California, a well-established plant will produce either leaves or a cone each year, sometimes both in the same season. Obtaining *D. sonorense,* however, is quite difficult, and cultivated plants or seeds are seldom available. I can recommend this species highly for use in any hot, dry, climates that experience occasional freezes. The growth rate of *D. sonorense* is somewhat slow, but its beauty and hardiness make it worth the investment of time.

The conservation status of *Dioon sonorense* is difficult to assess. The plants occur as scattered small colonies in very rough, more or less uninhabited terrain, making a census all but impossible. The colonies I have investigated have almost no regeneration taking place—young plants were not in evidence. This lack of regeneration is no doubt the result almost entirely of hostile weather conditions, since no human or animal interference was observed. Because of the lack of large colonies and sparse regeneration, *D. sonorense* must be considered extremely endangered.

Dioon spinulosum Thiselton-Dyer 1883b

PLATES 215, 216

Dioon spinulosum, the epithet derived from *spinulosus,* Latin for spiny, referring to the spiny leaflet margins, is called *palma de dolores, palma de chicle, chicalitos,* and *coyolillo.* **Stems** arborescent, solitary, usually not branched above or below ground unless damaged, 3–12 m (10–39 ft) tall or more, 18–25 cm (7.1–10 in) in diameter, base of large stems usually twice the diameter of the midpoint. Roots are often exposed for long distances on cliffs they explore for soil. The lower portions of old trunks lose all indication of leaf bases and form a smooth skin, in some cases old trunks showing conspicuous enlarged transverse collars that may denote periods of active growth. **Leaves** numerous, gracefully arching, gray-green, 1.5–2 m (4.9–6.6 ft) long, 30–40 cm (12–16 in) wide, flat. Petiole long and unarmed in seedlings and juvenile leaves but absent in leaves of mature plants. Leaflets in 80–117 pairs, deflexed at the apex, glaucous green, in aging plants the lower leaflets gradually reduced to spines that continue to the base of the leaf, median leaflets 15–20 cm (6–8 in) long, 1–1.5 cm (0.4–0.6 in) wide, margins revolute, with five to eight short spines but the spines sometimes almost lacking in very old plants, both margins tapering equally toward the pungent apex. **Female cones** solitary, cylindrical ovoid, 35–50 cm (14–20 in) long, 20–27 cm (8–11 in) in diameter, densely tan tomentose, weighing as much as 18 kg (40 pounds), becoming pendent and hanging below the leaves. Peduncle 20–30 cm (8–12 in) long, 5–5.5 cm (2–2.2 in) in diameter, lengthening as it matures so as to allow the cone to become pendent below the leaf crown, densely tomentose, with numerous cataphylls along its entire length. Sporophylls 7.5–8 cm (3–3.2 in) long, closely overlapping so as to keep the sporophyll tips tight against the cone, densely tomentose, apex rounded or obtuse. Sporophyll face broad triangular, 6.5–7 cm (2.6–2.8 in) high, 7.5–8.5 cm (3–3.3 in) wide. Sarcotesta yellow when ripe. Sclerotesta 4–5.5 cm (1.6–2.2 in) long, 2.5–3.5 cm (1–1.4 in) in diameter, light brown, smooth. Chalaza drawn out, ending in a distinct pit. **Male cones** solitary, erect until the pollen is shed, then leaning, cylindrical ovoid, 21–50 cm (8.3–20 in) long, 10–13.7 cm (4–5.4 in) in diameter, densely tan tomentose. Peduncle short, cone appearing sessile. Sporophylls to 5 cm (2 in) long. Sporophyll face broad triangular, 14–25 mm (0.6–1 in) high and wide, densely tomentose, with an obtuse tip. Sporangia in two patches, covering the entire underside of the sporophyll except for a distinct groove separating the two halves. **Habitat:** Lowland tropical evergreen rain forest on limestone hills and cliffs, at elevations of 20–300 m (66–980 ft). Rainfall averages more than 2000 mm (79 in) annually, falling mainly in summer. Summers are hot and humid with frequent rains, and winters, about November–March, warm and generally dry. **Distribution:** Mexico, Oaxaca and, formerly, Veracruz states, from near Tierra Blanca, Veracruz, in the north, to Lago Catemaco, Veracruz, to the east, extending to south of San Juan Bautista Tuxtepec, Oaxaca.

When William T. Thiselton-Dyer described *Dioon spinulosum* in 1883, he mistakenly gave the collection locality as Progreso, Yucatán, Mexico. Since *D. spinulosum* has never been found growing wild in Yucatán, the specimen sent to Thiselton-Dyer was doubtless from a cultivated plant. The natural populations of *D. spinulosum* occurred only in the southern portion of Veracruz and Oaxaca. The specimens used by Thiselton-Dyer were from immature plants and he did not realize the large size this species would reach. Later expeditions by Charles J. Chamberlain and Edward A. Howard disclosed the truly magnificent proportions this cycad can attain. *Dioon spinulosum* is the second tallest cycad in the world and on rare occasions has been known to exceed 16 m (52 ft) in trunk height. Sometimes these cycads will be seen breaking through the forest canopy and being exposed to full sun, but generally they stay well below the canopy and are not exposed to direct sunlight.

Dioon spinulosum is found on limestone hills in rain forest at low elevations. The plants commonly grow out of cracks and pockets in solid rock. Seeds germinate in small fissures in the cliffs, and growth can be painfully slow until the roots find their way to a pocket of soil. I have observed large plants growing out of a small hole or fissure in a limestone cliff with one large root connecting it to a patch of soil some 10 m (33 ft) distant.

Indians native to the habitat of *Dioon spinulosum* have used the large seeds as a food item. Seeds are shelled, ground, then washed several times in running water to remove the poisons that are contained in all cycad seeds. The end product is a flourlike substance that is almost pure starch, used to make tortillas. Some even chew the pitchlike sap as gum, from which the native name *chicalitos* is derived. The seed shell is a toy for children, and the leaves are used for decoration. In the 1970s and 1980s, the sale of stems for the nursery trade was a major source of income in some areas.

In cultivation, *Dioon spinulosum* is one of the most trouble-free cycads. It will not only withstand full sun but some frost exposure as well. When planted in sunny locations, the growth rate seems to be more rapid than if grown in a shady position. Seedlings grow rapidly and in the span of a few years can become sizable plants. Plants do better if placed in a somewhat shady location with dampness at the roots at all times. The growth rate is relatively rapid if sufficient fertilizer and water are provided throughout the growing season, generally March–September. Soil should be loose and damp, containing a good quantity of humus. As with most cycads, good drainage is essential. *Dioon spinulosum* has few pest problems. Occasionally, infestations of mealybugs or scale insects occur but generally only when the plant is in a stressed condition. These pests are easily controlled with periodic applications of the proper insecticide. Grasshoppers or other chewing insects are usually only a problem when new leaves are emerging.

In its habitat in Oaxaca, *Dioon spinulosum* is a very common cycad, but as early as 1919 Chamberlain wrote, in *The Living Cycads,* “Beautiful specimens, which might have been the pride of any conservatory, had been cut down to get the cones, because it was easier to cut the tree than to climb it.” In the 1970s and 1980s, many hundreds of thousands of “cuts” have been exported from Mexico. Commercial collectors have contracted with local Indians to supply so many plants. To fill the orders, many cycads 3–9 m (10–30 ft) tall have been cut down so that the top 60 cm (24 in) can be cut off and sold. Even with all this devastation, *D. spinulosum* is still a reasonably common plant in Mexico, but this destruction cannot go on indefinitely without affecting the survival of this species in the wild. Unlike other cycads, *D. spinulosum* does not often sucker from the remaining rootstock after the upper portion of the plant has been removed. The portion of the trunk that is left slowly rots away, and a cycad that has taken hundreds of years to develop is just a memory. *Dioon spinulosum* is considered threatened.

Dioon tomasellii De Luca, Sabato & Vázquez-Torres 1984

PLATES 217, 218

Dioon tomasellii, named in honor of Ruggero Tomaselli (1920–1982), professor of botany at the University of Pavia and president of the Italian Botanical Society, is called *palma de la Virgen* in Durango, and *palma* and *palmita* in Guerrero, Michoacán, and Nayarit. **Stems** cylindrical, erect, usually no more than 1 m (3.3 ft) high, occasionally more than 2 m (6.6 ft) high in very old specimens, 25 cm (10 in) in diameter, older plants often suckering from the base. **Leaves** numerous, straight, dark green, rigid and ascending, 1.5–2 m (4.9–6.6 ft) long, 30–36 cm (12–14 in) wide, emergent leaves densely brown hairy, soon becoming glabrous except on the rachis and undersides of the leaflets. Petiole terete or subterete, 15–24 cm (6–9.4 in) long, 8–14 mm (0.3–0.6 in) in diameter, unarmed. Rachis subterete. Leaflets in 93–104 pairs, subopposite, lanceolate to linear lanceolate, falcate to subfalcate, inserted at right angles to the rachis, median leaflets 14–18 cm (5.5–7.1 in) long, 7–12 mm (0.3–0.5 in) wide at the midpoint of the leaf, margins entire or sometimes with one or two spines on the leading edge near the leaflet apex, rarely with one spine on the lower margin near the apex. **Female cones** solitary, ovoid, 20–30 cm (8–12 in) long, 15–20 cm (6–8 in) in diameter. Sporophyll face long triangular, 7–8 cm (2.8–3.2 in) high, 4–5 cm (1.6–2 in) wide, densely woolly, apex abruptly curved backward and downward. Sarcotesta yellow when ripe. Sclerotesta globose to ovoid, 24–30 mm (0.9–1.2 in) long, 21–25 mm (0.8–1 in) in diameter, light brown, smooth, with 12–15 faint longitudinal ridges. **Male cones** solitary, long cylindrical, 35–50 cm (14–20 in) long, 8–10 cm (3.2–4 in) in diameter, densely light brown tomentose. Sporophylls 2.5–4 cm (1–1.6 in) long. Sporophyll face pointed above, rounded below. **Habitat:** Oak and pine-oak forest in steep-sided canyons and woodlands at elevations of 600–1850 m (2000–6100 ft). Rainfall averages 1000–1500 mm (39–59 in) annually, falling mainly in summer. **Distribution:** Mexico, in Durango, Guerrero, Jalisco, Michoacán, and Nayarit states, Sierra Madre Occidental and Sierra Madre del Sur.

My first encounter with what was to be *Dioon tomasellii* was in the early 1960s. I was driving down the western coast of Mexico and made a stop at a roadside restaurant in the state of Nayarit where the road to San Blas turned off. Herberto Parra, a jaguar hunter, owned the restaurant. He ran a small nursery by the restaurant in which he was growing a *Dioon* I was not familiar with. I questioned him about it, and he told me he had found it in the local mountains while on the trail of a jaguar but would not disclose its exact location. I purchased three plants from him that are still in my collection.

Dioon tomasellii does quite well in cultivation but has two drawbacks, at least in the climate of southern California. Plants are very slow growing, and more importantly, they are shy about producing new leaves and cones. Often, the old crown of leaves must die completely before new leaves are produced. This can sometimes take as long as 3 years or more! The proper feeding of these plants does not seem to help, and possibly the missing requirement is heat, as this species endures high temperatures in its habitat. The availability of seeds is poor, and as *D. tomasellii* does not cone well in cultivation, artificially produced seed is not common.

When *Dioon tomasellii* was described in 1984, it included all the populations of *Dioon* on the western coast of Mexico from Sonora to Guerrero. The species was divided into two varieties, *sonorense,* which included only those plants from Sonora and northern Sinaloa, and variety *tomasellii,* which included the remaining populations. In 1998 Jeffrey Chemnick, Timothy J. Gregory, and Silvia Salas-Morales published a revision of *D. tomasellii* in which variety *sonorense* was elevated to the status of species.

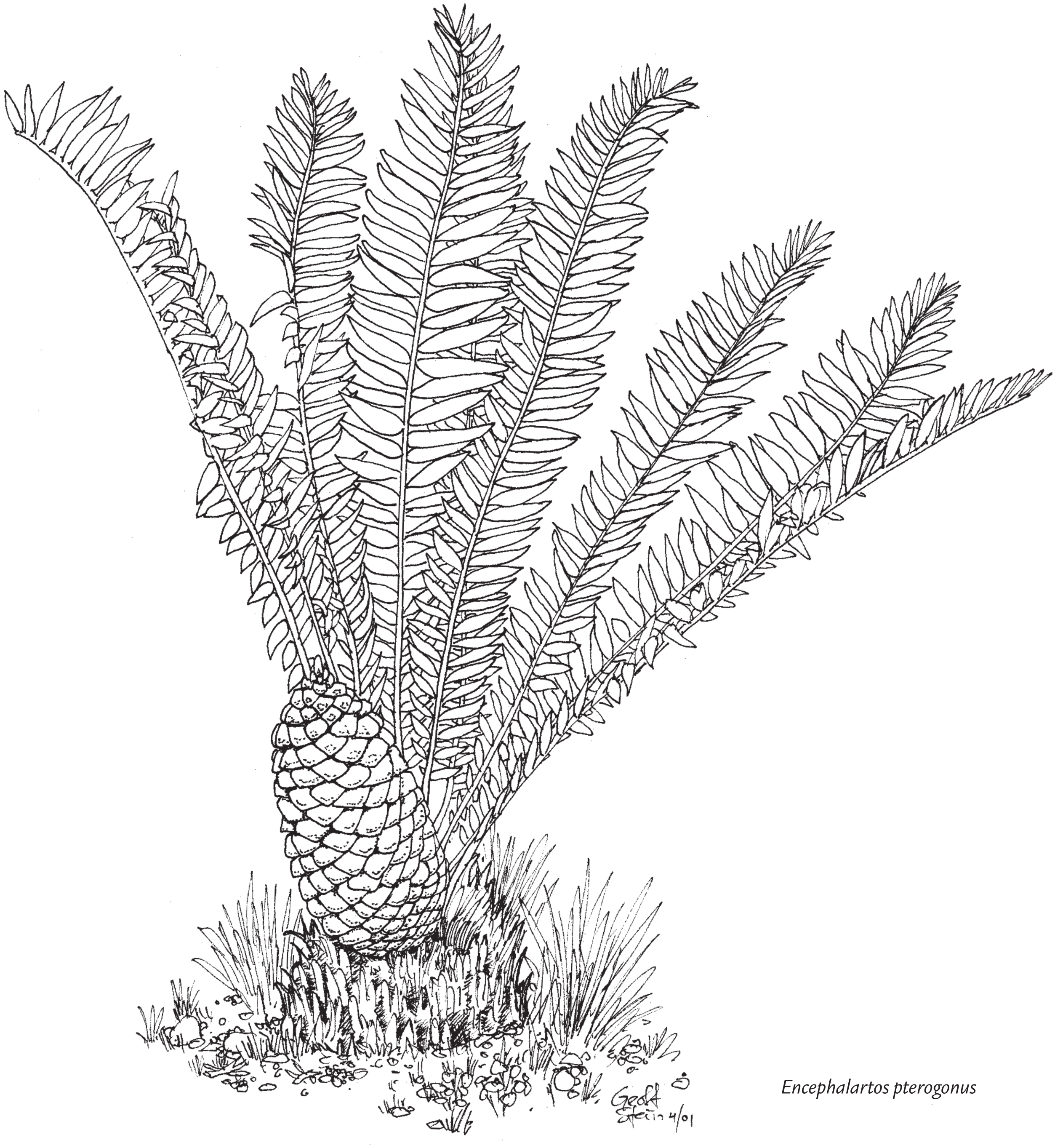
The conservation status of *Dioon tomasellii* is good. Seed production in its habitat is cyclical, and several years may pass between major coning events. In spite of this, *D. tomasellii* has good regeneration in the wild, and numerous juvenile plants and seedlings have been seen at each colony investigated. Land in its habitat is generally used for raising cattle, so little pressure from land clearance has been put on these colonies. I have never observed *D. tomasellii* damaged as a result of cattle or the people who raise them. *Dioon tomasellii* is often common locally, and its range appears to be quite extensive. For these reasons, I feel that *D. tomasellii* is not threatened.

Encephalartos Lehmann 1834

The name *Encephalartos* is derived from the Greek, meaning "bread in head" and referring to the large central pith of the stem that is used by Africans to produce flour from which they make a breadlike food. Sixty-three species (type, *E. longifolius*) with more in the process of being described. Chromosome number $2n = 18$. *Encephalartos* together with most of the other cycad genera constitute the family Zamiaceae.

Stems ranging from subterranean species with stems about 15 cm (6 in) in diameter to arborescent species with stems to 15 m (49 ft) tall. Many of the species with larger stems produce basal offsets. These offsets in time grow into stems that change the overall plant from a single stem into a large clump.

Leaves extremely variable in length, 60 cm (24 in) to 6 m (20 ft) , the surface varying from dull to glossy, the color from blue-gray though yellow-green to dark green. Rachis curved inward to straight to curved strongly back-



Encephalartos pterogonus

ward and downward. Leaflets upright in a V formation, flat, or drooping, their insertion almost at right angles to the rachis or overlapping in an upward or downward direction, leaflet width varying from narrow to broad. Leaflets may be unarmed or heavily armed with spines that are short to lobed and angled forward.

Female cones almost as variable as the leaves. Cones may be solitary or as many as eight. Size ranges from about 80 cm (32 in) tall and 40 cm (16 in) in diameter to 30 cm (12 in) tall and 15 cm (6 in) in diameter. Cones may be sessile or have a well-developed peduncle, and be upright or decumbent. Color varies from blue-gray through lime green, dark green, brown, maroon, yellow, orange, pink, and red. The surface of the facets on the sporophyll face ranges from smooth through pimpled to wrinkled, and from glabrous to thickly tomentose.

Male cones usually more numerous than female cones, about the same as female cones in color range. Peduncles tending to be longer than those of female cones, in extreme cases somewhat pendent and snakelike in form.

Habitat: Exceedingly variable, from desert conditions to savanna and forest, but it appears that no species of *Encephalartos* occurs in rain forest. Elevational range is from sea level to 2400 m (8000 ft), at which plants are regularly subjected to snow and freezing.

Distribution: Africa, the range of *Encephalartos* covering a large area from Sudan, Central African Republic, Nigeria, and Ghana in the north to South Africa in the south. Most of the species are located in eastern and southern Africa in the Democratic Republic of the Congo (Zaire), Uganda, Kenya, Tanzania, Zambia, Zimbabwe, Mozambique, and South Africa. Only *E. barteri* is known from the west coast of Africa.

Because of its wide range of leaf forms and colors, *Encephalartos* has always been sought by botanical gardens and collectors. Almost all species are generally easy to grow, and growth is rapid if the proper conditions are provided. In the African countries where the plants are native, but particularly in South Africa, the various species are popular lawn plants because of their distinctive form. In more recent years, their use as landscape plants for public buildings and parks has increased dramatically.

The common name for *Encephalartos* is bread palm because of its use by the Africans as a source of starch. The natives make a meal from the starchy seeds, sometimes also the pith from the center of the stem. The poisonous constituents are removed by grinding and repeated washing of the flourlike end product. Apparently, this starch is used only during times of crop failure or famine and has generally been discontinued in more recent times. All species of *Encephalartos* are listed in Appendix I of CITES.

Encephalartos aemulans Vorster, Robbertse & S. van der Westhuizen 1990

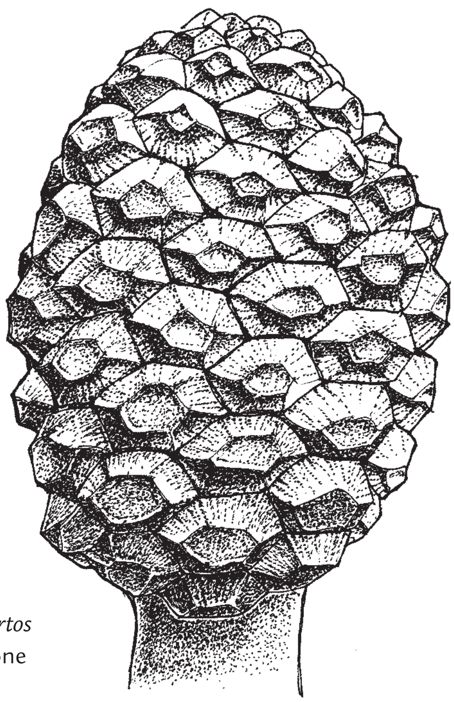
PLATES 219–222

The epithet for *Encephalartos aemulans* is Latin for rivaling and meaning more or less equaling, referring to the similarity in size and shape of the female and male cones. Stems arborescent, erect, unbranched but usually suckering from the base, to 1.5 m (4.9 ft) long, rarely as long as 3 m (10 ft), about 35 cm (14 in) in diameter, crown densely tomentose. Leaves numerous, straight, rigid, glossy dark green, about 1.5 m (4.9 ft) long, 25 cm (10 in) wide. Petiole 7–11 cm (2.8–4.3 in) long. Leaflets narrowly elliptical, slightly falcate, angled forward about 15–35°, keeled and gradually reduced to prickles toward the base, median leaflets not overlapping or only very slightly so, 12.5–15 cm (5–6 in) long, 16–18 mm (0.6–0.7 in) wide, with an apical spine, margins slightly revolute, with one to three teeth on the upper margin, one or two on the lower. Female cones one to four, broad ellipsoid, 35–41 cm (14–16 in) long, 20–23 cm (8–9.1 in) in diameter, green obscured by a covering of dense brown tomentum. Peduncle 2–2.5 cm (0.8–1 in) long but buried in the crown, the cone appearing sessile. Sporophyll face hexagonal, 30–40 mm (1.2–1.6 in) high, 44–57 mm (1.7–2.2 in) wide, the central facet slightly raised and covered with small nodules. Sarcotesta bright red when ripe. Sclerotesta ellipsoid to slightly ovoid, 23–26 mm (0.9–1 in) long, 16–18 mm (0.6–0.7 in) in diameter, with 10–14 longitudinal ridges. Chalaza 5–8 mm (0.2–0.3 in) in diameter and composed of numerous shallow pits. Male cones one to four, more or less upright, 29–33 cm (11–13 in) long, 14–18 cm (5.5–7.1 in) in diameter, lemon yellow under a covering of thick brown tomentum. Peduncle 5–6 cm (2–2.4 in) long, buried in the crown, the cone appearing sessile. Sporophyll face rhomboid, 22–32 mm (0.9–1.3 in) high, 30–35 mm (1.2–1.4 in) wide, not projected into a beaklike structure, terminal facet covered with small nodules, the facets surrounding it smooth. Sporangia generally in a single patch but sometimes divided into two or three patches and covering the entire underside of the sporophyll. Habitat: South-facing sandstone cliffs in short grassland fully exposed to the sun, at elevations of 600–1100 m (2000–3600 ft). Rainfall averages 600–800 mm (24–32 in) annually, falling mainly in summer. Light winter frosts would be expected. **Distribution:** South Africa, northern KwaZulu-Natal, Ngotshe district, near Vryheid.

Encephalartos aemulans is a handsome cycad, somewhat resembling *E. natalensis.* In fact, it was referred to as a form of *E. natalensis* for many years and was known as the "woolly *natalensis.*" *Encephalartos aemulans* differs from *E. natalensis* by its almost equally sized female and male cones, covered by a thick layer of brown tomentum, and its narrower leaflets with marginal and apical spines. Adult plants of *E. aemulans* are easily recognized, and the seedling leaves are distinctive enough to distinguish the two species easily. Seedlings of *E. aemulans* have flatter, more flexible leaflets with much smaller marginal spines whereas seedlings of *E. natalensis* have leaflets that are very stiff, somewhat channeled, and sport longer marginal spines.

Encephalartos aemulans is not as rapid a grower as *E. natalensis,* but it responds well to the same general cultivation requirements. Seedlings require some protection, but juvenile and adult plants do better in full sun and are mildly frost tolerant.

Encephalartos aemulans can be considered as not threatened. There are several hundred mature plants in the known colony, and regeneration is prolific. All plants occur on private property, but the very restricted range of the species, and the fact that mature plants have been removed from the habitat more recently, leave some doubt as to its continued safety. Every effort should be made to assure its protection from poachers and its survival in the wild.



Encephalartos female cone

Encephalartos altensteinii Lehmann 1834

PLATES 223, 224

Encephalartos altensteinii is named in honor of Karl Altenstein (1770–1840), a Prussian statesman who fostered education. **Stems** arborescent, erect, sometimes decumbent when growing in shallow soils and on steep slopes, to 5 m (16 ft) tall, 25–35 cm (10–14 in) in diameter, light tan, with prominent leaf scars. **Leaves** numerous, bright green or yellowish green, usually straight but sometimes curved slightly backward and downward, 1.5–2 m (4.9–6.6 ft) long, to 35 cm (14 in) wide, slightly to strongly keeled. Petiole 10–30 cm (4–12 in) long, 1.5 cm (0.6 in) in diameter, semiterete and unarmed. Leaflets in 100 pairs or more, lanceolate, evenly spaced and not crowded, angled forward 30–40°, lower leaflets reduced in size but not spinelike, median leaflets 12.5–17 cm (5–6.7 in) long, 19–25 mm (0.8–1 in) wide, margin with none to three spines, more in juvenile plants, and adult plants except those from Bushmans River often with a smooth margin and only a terminal spine. **Female cones** usually one to five, cylindrical ovoid, 40–50 cm (16–20 in) long, 20–30 cm (8–12 in) in diameter, greenish yellow to golden yellow. Peduncle short, cone appearing sessile. Sporophyll face 3.5 cm (1.4 in) high, 4.5–5 cm (1.8–2 in) wide, deeply wrinkled and lightly tomentose. Sarcotesta scarlet to bright red when ripe. Sclerotesta short ovoid, 29–33 mm (1.1–1.3 in) long, 19–21 mm (0.7–0.8 in) in diameter, the surface generally smooth except for 11–13 longitudinal ridges. **Male cones** usually one to five, subcylindrical, 40–50 cm (16–20 in) long, 12–15 cm (4.7–6 in) in diameter, greenish yellow to golden yellow. Peduncle 5–10 cm (2–3.9 in) long, 4–5 cm (1.6–2 in) in diameter. Sporophyll face drawn out into a down-curved beak 1.5–2 cm (0.6–0.8 in) long, base 12 mm (0.5 in) high, 20–28 mm (0.8–1.1 in) wide. Sporangia in a single patch covering the entire underside of the sporophyll. **Habitat:** Low coastal bush and forest from sea level to about 250 m (820 ft), usually in full sun in exposed situations but often in full shade in forested areas. Rainfall is 875–1000 mm (34–39 in) annually, falling mostly in summer. The climate is hot in summer and cold in winter but frosts are rare. **Distribution:** South Africa, coastal areas from the Bushmans River, Eastern Cape province, north and east almost to the border with KwaZulu-Natal province.

Encephalartos altensteinii was described in 1834 by Johann Georg Christian Lehmann, director of the Botanical Gardens, Hamburg, Germany, based on material obtained from Christian Friedrich Ecklon and Karl Ludwig Philipp Zeyher, professional collectors working in the Cape province, South Africa, in the 1820s.

Because of its great numbers and immense range, *Encephalartos altensteinii* is probably the best known of the South African species of the genus. The oldest known pot plant is a specimen of *E. altensteinii* (for many years misidentified as *E. longifolius*) that has been in cultivation at the Royal Botanic Gardens, Kew, England, since 1777. Specimens can be found in botanical gardens and conservatories throughout the world. This popularity is mainly because of its abundance in habitat but also its ease of horticulture, rapid growth, and handsome appearance. In the Eastern Cape province, hundreds of plants can be seen decorating the front lawns of homes and public buildings, and they are often planted on graves in some of the old cemeteries.

The closest relatives of *Encephalartos altensteinii* are *E. lebomboensis, E. longifolius,* and *E. natalensis*. *Encephalartos altensteinii* can be distinguished from *E. lebomboensis* by its unarmed petiole and its spaced rather than overlapping leaflets, from *E. longifolius* by the light green color of its flatter leaves and its multiple yellow cones, and from *E. natalensis* by the absence of reduced spinelike leaflets on its petiole.

Encephalartos altensteinii is a variable species, with specimens in the eastern part of its range with fewer marginal spines on the leaflets than those farther west. The population from the Bushmans River (possibly now extinct in habitat) has longer, flatter, spinier leaflets. Robert Allen Dyer was of the opinion that the Bushmans River plants were of hybrid origin, having been mixed with *E. trispinosus,* which grows with it. This may be true as it has proved to be very difficult to produce viable seed on plants in my collection.

Encephalartos altensteinii is without doubt the species of the genus most frequently involved in natural hybridization. Natural hybrids are known to occur with *E. arenarius, E. latifrons, E. trispinosus, E. villosus,* and possibly *E. princeps.* Some of the hybrids are more or less intermediate between the parents whereas others display leaves more consistent with one of the parents, usually the female, which in most cases seems to contribute more of its characteristics to the offspring. In the Fish River area, natural hybridization has taken place for so long that second- and third-generation hybrids can be found. The mixture of characteristics in the cycads of this area has added greatly to the problems of their taxonomic classification.

In cultivation, *Encephalartos altensteinii* is very ornamental, hardy, and easily grown. It adapts well to full sun or full shade and is able to withstand several degrees of frost without leaf burn. This species is equally at home as a pot plant or when used in the landscape. Given the proper conditions, growth is rapid, and a large specimen can be produced in very few years.

The conservation status of *Encephalartos altensteinii* remains secure. Although hundreds have been removed from the wild for the nursery trade, and hundreds more destroyed by land clearance, *E. altensteinii* is still a common plant. Reproduction in habitat remains good, and the species can be considered not threatened.

Encephalartos aplanatus Vorster 1996a

The epithet for *Encephalartos aplanatus* is derived from *a-*, not, and *planities,* Latin for flat, thus not flat, referring to the somewhat undulate leaflet margins. **Stems** mostly subterranean but the apex usually above ground level, the exposed portions densely tomentose, with a single crown and generally not known to sucker. **Leaves** few, as many as 10 in large, old specimens, to 3.5 m (11.5 ft) long and 60 cm (24 in) wide. Petiole to 20 cm (8 in) long, covered with persistent, shaggy, off-white tomentum. Leaflets angled forward about 75°, opposing leaflets at an angle of slightly less than 180° to each other, thus almost in the same plane, basal leaflets gradually reduced to prickles, median leaflets very narrowly ovate and tapering to an acute but not pungent apex, dark glossy green, relatively soft textured, to 30 cm (12 in) long and 4 cm (1.6 in) wide, underside of the leaflet striate but not corrugated, margin sparsely toothed or very rarely entire and somewhat undulate. **Female cones** usually solitary, rarely two, about 40 cm (16 in) long and 12 cm (4.7 in) in diameter, at first dark green, turning bright orange-yellow when mature. Peduncle to 6 cm (2.4 in) long, stout. Sporophyll face flattened, about 2.5 cm (1 in) high and 4.5 cm (1.8 in) wide, smooth, glabrous, the facets indistinct, with a sharp transverse ridge that is not fringed. Sarcotesta bright red when ripe. Sclerotesta ellipsoid with almost truncate ends, about 25 mm (1 in) long, 13–15 mm (0.5–0.6 in) in diameter. **Male cones** usually one to three, erect, to 65 cm (26 in) long, 8–10 cm (3.2–4 in) in diameter, at first green, turning pale yellow when mature. Peduncle to 22 cm (8.7 in) long. Sporophylls generally flat, about 14 mm (0.6 in) high and 23 mm (0.9 in) wide, smooth, glabrous, the facets indistinct, with a distinct ridge on the lower surface that is not fringed or only slightly so. Sporangia in a single more or less uniform patch covering the entire lower surface of the sporophyll. **Habitat:** Steep, dry ravines in fairly dense shade cast by deciduous forest. **Distribution:** Swaziland, known only from a small area in the northeastern part of the kingdom near the border with Mozambique.

The existence of *Encephalartos aplanatus* has been known since the 1940s as the "Swaziland giant *villosus.*" It was never common or widespread and was restricted to a small area of northeastern Swaziland.

Encephalartos aplanatus grows well from seed, and larger transplanted specimens seem to reestablish without problems. Seedlings have broad, blunt leaflet apexes, easily separating them from seedlings of any of the various forms of *E. villosus.* As in typical *E. villosus,* the growth rate of *E. aplanatus* is rapid. Frost hardiness can be expected to be similar to that of *E. villosus. Encephalartos aplanatus* does best in a shady situation, and specimens in too much sun can be expected to have yellow or burned foliage.

The conservation status of *Encephalartos aplanatus* is not good. The numbers, probably never high, have regrettably been reduced by illegal collection almost to extinction. Because of the nature of the area where it occurs, it is unlikely that it can be adequately protected. Evidence of its reduction is that *E. aplanatus* no longer exists in some localities where it was known to occur in 1945. The population is now dangerously small, and poaching is still occurring. For these reasons, *E. aplanatus* must be considered extremely endangered, on the brink of extinction in the wild. Although *E. aplanatus* could be found in several private collections and gardens in 1996, it was only in two public collections in South Africa, the Pretoria National Botanical Garden and the Lowveld National Botanical Garden, Nelspruit. The plants in the Lowveld National Botanical Garden will be producing seeds, and that may prevent the extinction of this interesting species.

Encephalartos arenarius R. A. Dyer 1956

PLATES 225, 226

The epithet for *Encephalartos arenarius* is derived from *arena,* Latin for sand, referring to the stabilized sand dunes upon which this cycad grows. **Stems** solitary or suckering from base, erect, to 1 m (3.3 ft) tall, rarely as long as 3 m (10 ft) but then usually leaning or decumbent, 20–30 cm (8–12 in) in diameter, crown always with a quantity of light brown wool that is especially heavy just before the production of new leaves or cones. **Leaves** numerous, upright, then spreading, rigid, 1–1.5 m (3.3–4.9 ft) long, 25–35 cm (10–14 in) wide, slightly keeled, apex curved slightly to strongly backward and downward, fresh foliage with a glaucous bloom, disappearing with age. Petiole round, 15–20 cm (6–8 in) long, 1.5–2 cm (0.6–0.8 in) in diameter. Leaflets overlapping in the upper part of the leaf, toward the base more widely spaced, spreading, reduced to prickles above the petiole, median leaflets 12–16 cm (4.7–6.3 in) long, 2.5–4 cm (1–1.6 in) wide, margins flat, the upper margin usually entire, rarely with one small lobe or spine, the lower with three or four lobes, the lobes usually slightly twisted out of the leaflet plane. **Female cones** solitary, barrel shaped, 35–60 cm (14–24 in) long, 20–30 cm (8–12 in) in diameter, light green with a slight glaucous bloom. Peduncle 6–10 cm (2.4–3.9 in) long, 5–6 cm (2–2.4 in) in diameter. Sporophylls with an outwardly projecting beak 1.5–2 cm (0.6–0.8 in) long, the surface indistinctly wrinkled, the facets distinct, especially the terminal facet, the inside of the sporophyll turning coral red as seeds ripen. Sporophyll face 3.5 cm (1.4 in) high, 7–8 cm (2.8–3.2 in) wide. Sarcotesta coral red to deep red when ripe. Sclerotesta 30–34 mm (1.2–1.3 in) long, 19–22 mm (0.8–0.9 in) in diameter, the surface smooth except for 9–12 low longitudinal ridges. **Male cones** solitary, spindle shaped, 30–50 cm (12–20 in) long, 8–15 cm (3.2–6 in) in diameter, light green. Peduncle 4–7.5 cm (1.6–3 in) long, 3.5–4 cm (1.4–1.6 in) in diameter. Sporophyll face 1.3–1.5 cm (0.5–0.6 in) high, 2.5–3 cm (1–1.2 in) wide, projecting about 1 cm (0.4 in), smooth to slightly wrinkled. Sporangia in a single patch with a sterile notch at the apical end and covering most of the underside of the sporophyll. **Habitat:** Stabilized sand dunes, usually in the shade of coastal scrub. Rainfall is 725–875 mm (29–34 in) annually, occurring at any time of the year. Summers are hot and dry, and no frost occurs in winter. **Distribution:** South Africa, Eastern Cape province, Alexandria district, mainly the Kaba Valley, and a very limited area near the coast.

The first recognition of the plant that was to become known as *Encephalartos arenarius* was recorded by Murray Ross Henderson (1945). The specimen he referred to was in cultivation at Kirstenbosch National Botanical Garden near Cape Town, South Africa. John Hutchinson and George Rattray (1933) had identified this same plant as *E. latifrons.* It was not until 1953, when Eily Edith Agnes Gledhill reported the discovery of a colony of *Encephalartos* on the inland sand dunes of the Alexandria district in Kaba Valley, that this cycad was recognized as undescribed. In 1954, Gledhill and Robert Allen Dyer of the National Herbarium in Pretoria inspected the colony together and collected herbarium specimens and field notes, forming the basis for the description of *E. arenarius* in 1956.

The closest relative of *Encephalartos arenarius* is certainly *E. latifrons* of Trapps Valley, not many miles distant from the Kaba Valley. The similarities between these two species are superficial, and they can be easily distinguished when one is familiar with both species. The stems of *E. arenarius* seldom reach 3 m (10 ft) in length and at that size are usually decumbent whereas stems of *E. latifrons* of the same length are always erect. The leaves of *E. arenarius* are curved slightly backward and downward, with leaflets not crowded and light green to glaucous green, whereas leaves of *E. latifrons* are curved strongly backward and downward, with leaflets tightly packed, overlapping, and interlocked, and dark green. The cones of *E. arenarius* are light green, with the sporophyll faces slightly wrinkled, whereas the cones of *E. latifrons* are olive green, and densely pimpled and wrinkled.

Over most of its area, *Encephalartos arenarius* does not vary to any great extent in leaf characteristics. There have been some small colonies found of a cycad dubbed the "blue *arenarius*" that differ in a number of respects from the typical species. It is of smaller stature, with short leaves curved strongly backward and downward, of a blue-gray color similar to that of *E. horridus.* All the specimens I have seen of this form have been regular in their characters, and it may well be an undescribed taxon. In any case it is a beautiful plant and worthy of mention.

Naturally occurring hybridization of *Encephalartos arenarius* with *E. altensteinii* is suspected but not known for certain. I have an artificial hybrid between *E. arenarius* and *E. trispinosus* that looks promising. An artificial hybrid between *E. arenarius* and *E. latifrons* has also been reported.

Encephalartos arenarius is one of the finest of the South African species of the genus. Its numerous leaves curved backward and downward, and broad, lobed leaflets make it exceptionally beautiful. Added to this are fast growth, ease of horticulture, and frost tolerance unexpected in a plant native to a habitat that does not experience frost. The single problem associated with this cycad is the difficulty in obtaining one. Seed is not often available, and though older plants are quite prolific in the production of offsets, there are never enough to fill the demand.

In the more than three decades that I have grown *Encephalartos arenarius,* it has proved to be one of the easiest species of the genus in cultivation. There has been no leaf damage as a result of frost at temperatures as low as −4°C (25°F). At the other extreme, plants in full sun have not suffered leaf burn at temperatures as high as 43°C (109°F) combined with low humidity. As with most sand-dwelling cycads, *E. arenarius* is easy to reestablish and grows rapidly. In cultivation it cones reasonably well, and with patience viable seed can be produced. Seedlings grow rapidly, and with proper care a plant with a stem the size of a tennis ball may be produced in about 5 years. As with most species of the genus, *E. arenarius* responds well to frequent applications of a balanced fertilizer.

Encephalartos arenarius was once quite plentiful within its range, but in more recent times large numbers have been destroyed or removed from habitat. Early in the 1900s, many plants were lost as a result of land clearance for farming, and later for brush removal from steep hillsides to promote grass growth for grazing dairy cattle and goats. In more recent times, large numbers of plants have been removed for collectors and the nursery trade. As a result of the limited numbers remaining in habitat, this species must be considered endangered.

Encephalartos barteri Carruthers ex Miquel 1868

PLATES 227, 228

Encephalartos barteri, named in honor of Charles Barter (d. 1859), who discovered this cycad where it was first collected, near Jebba, northern Nigeria, is called *adamgme krobo,* ghost palm, by the Pardi Attar tribe of Africa. The name, according to the Reverend C. Schonfeld of the Gold Coast Basel Mission in 1865, expresses the absence of all virtues from this plant as compared to the valuable oil palm. In 1890 Sir A. Moloney recorded an alternative translation, attributing malignant qualities to this cycad. Two subspecies of *E. barteri* are recognized: *barteri* (described here) and *allochrous.* **Stems** solitary or suckering from the base, subterranean, rarely more than a few centimeters above the ground because of the action of strong contractile roots, to 30 cm (12 in) long, 20–25 cm (8–10 in) in diameter, covered with gray tomentose leaf bases and cataphylls. Cataphylls linear to narrowly triangular, 45–60 mm (1.8–2.4 in) long, 7–15 mm (0.3–0.6 in) wide, the exterior covered with gray tomentum, the interior smooth and reddish brown. **Leaves** 10–20, usually 12, linear oblong, erect, bright green, 1–1.8 m (3.3–5.9 ft) long, 15–26 cm (6–10 in) wide, apex rounded, base gradually tapering. Petiole 6–10 cm (2.4–3.9 in) long, base swollen and densely covered with gray tomentum. Rachis above deeply grooved between the leaflets. Leaflets in about 80 pairs, lower leaflets gradually reduced to spines, median leaflets linear lanceolate, 10–16 cm (4–6.3 in) long, 1–1.5 cm (0.4–0.6 in) wide, flexible, tapering uniformly from the lower third to half to the straight pungent tip, abruptly narrowed at the basal attachment, margins with none to six more or less regularly spaced spiny teeth. Female cones one or two, erect, oblong ellipsoid, 12–35 cm (4.7–14 in) long, 8–15 cm (3.2–6 in) in diameter, dark olive green. Peduncle 5–12 cm (2–4.7 in) long, 1.5–3.5 cm (0.6–1.4 in) in diameter. Sporophyll face glabrous, deflexed, 45–56 mm (1.8–2.2 in) wide, 20–38 mm (0.8–1.5 in) high, the facets showing a surface with low undulate ridges or sometimes more or less rough and warty, the terminal facet somewhat brown tomentose and the outside margins slightly golden brown. Sarcotesta scarlet when ripe. Sclerotesta irregularly four-sided, 21–30 mm (0.8–1.2 in) long, 18–23 mm (0.7–0.9 in) in diameter, with about 13 longitudinal veins. Male cones one or two, erect, subcylindrical, 8–23 cm (3.2–9.1 in) long, 3–5 cm (1.2–2 in) in diameter, tapering slightly at the base, pale green with the terminal facets brownish tomentose. Peduncle 8–20 cm (3.2–8 in) long, 8–12 mm (0.3–0.5 in) in diameter, glabrous or tomentose. Sporophyll face deflexed, 8–10 mm (0.3–0.4 in) high, 12–17 mm (0.5–0.7 in) wide, the facets distinct. Sporangia in a single patch covering the entire undersurface of the sporophyll. Habitat: Sandstone or granite outcrops on steep slopes in tropical woodland savanna at elevations usually less than 400 m (1300 ft). There are distinct wet and dry seasons, but it is warm all year with temperatures averaging 24–30°C (72–86°F). Distribution: Africa, tropical West Africa in Nigeria, between Ilorin and Jebba in the western part of the country; Benin, Bergu province; and Ghana, in the catchment area of the Volta River; also reported from Uganda but probably misidentified since Denis Heenan was unable to locate them after an extensive search.

Encephalartos barteri was discovered by Charles Barter during William Balfour Baikie's second Niger Expedition of 1857 and was the first record of *Encephalartos* in tropical Africa. For a cycad that is common over an extensive range and that was discovered so early, *E. barteri* is not that well represented in botanical gardens and private collections. This may, at least in part, be the result of some difficulty in maintaining the plants under greenhouse conditions. There seem to be no problems when this species is grown in the ground in tropical or subtropical regions. In fact, *E. barteri* seems to respond well in cultivation by not having a deciduous period as it does in its natural habitat, probably because water is available the entire year. In the wild, this species is definitely deciduous, always dropping its leaves in the dry season. The cones emerge while it produces new leaves, shortly after the wet season begins in December or January.

The two subspecies of *Encephalartos barteri* appear to be quite dissimilar in most respects according to published data. The characteristics used to separate subspecies *barteri* from *allochrous* are as follows:

Subspecies *barteri*	Subspecies *allochrous*
Emergent leaves green	Emergent leaves brown
Stem mainly subterranean, not suckering	Stem 1–2.5 m (3.3–8.2 ft) tall, suckering freely from the base
Leaves to 1.8 m (5.9 ft) long	Leaves to 2 m (6.6 ft) long
Median leaflets to 16 cm (6.3 in) long and 1.5 cm (0.6 in) wide	Median leaflets to 26 cm (10 in) long and 2.2 cm (0.9 in) wide
Elevation less than 400 m (1300 ft)	Elevation more than 1200 m (3900 ft)

As can be seen from this comparison, the only distinction that could be used for distinguishing juvenile plants of the two subspecies in cultivation would be the color of emergent leaves. All the other characteristics would depend on having the field notes in hand, or a mature specimen for comparison.

In cultivation, seed germinates easily and growth is steady if not rapid. Offsets seem to transplant well into similar environments but do not thrive in greenhouse culture. In this respect the following narrative, quoted from David Prain (1909), is of interest:

> A barrel containing a number of stems of *Encephalartos barteri* was received at Kew in 1890 from the Botanic Station, Lagos. Some of these stems were distributed to various botanical gardens; others were planted at Kew. The plants, however, did not long survive; nor have stems subsequently received live for more than about three years.

In areas where climatic conditions are suitable, *Encephalartos barteri* should be grown as a garden plant. No problems seem apparent when this cycad is grown in full sun, and leaf burn is unusual. The cycad seems to have very little cold tolerance, with a few degrees of frost usually sufficient to cause eventual if not outright death of the plant. This may be due to the fact that the stem, possibly because of its underground habit, has very little woody tissue. The large subterranean stems are so soft that they can be easily cut through with a sharp knife.

It seems strange that a cycad with the extensive range and large numbers of *Encephalartos barteri* has never been used as an item of food. In almost all areas where cycads occur in large number, they have in one way or another been utilized as a famine food. The many tribes inhabiting the area where *E. barteri* grows seem never to have used it in any way. This could very well be tied to the plant's common name, *adamgme krobo,* ghost palm, perhaps attributing malignant qualities to it. The leaves of *E. barteri* have been used as decoration in churches during Palm Sunday, but this is the only native use of this cycad of which I am aware.

All conservation reports indicate that neither subspecies of *Encephalartos barteri* is considered threatened. Even though thousands of subspecies *barteri* were destroyed by earthmoving machinery and the subsequent flooding of a large area of its habitat during the construction of the dam across the Volta River in Ghana, many hundreds of thousands of plants survived. They are a common sight on the western slopes of the Volta Gorge and in the grasslands north of the dam as far as the Volta's confluence with the Afram. Only three areas of occurrence are known for subspecies *allochrous,* all within a fairly small area on the Jos Plateau. Leonard Eric Newton (1978) reported that regeneration was good even though the plants are restricted in distribution, and that people from the nearby villages did not disturb the habitats as the steep, rocky, slopes on which the cycads grow are useless for farming. Apparently, regeneration is good in all known areas of distribution of *E. barteri.*

Encephalartos barteri subsp. *allochrous* Newton 1978

The subspecific epithet for *Encephalartos barteri* subsp. *allochrous* is derived from *allo-,* Greek for other, and *-chrous,* colored, thus other colored and referring to the change of leaf color, emergent leaves being brown, changing to dark green at maturity. STEMS erect, later decumbent, usually unbranched but freely suckering from the base, 1–2.6 m (3.3–8.5 ft) long, to 30 cm (12 in) in diameter, otherwise as in subspecies *barteri.* LEAVES erect to spreading, brown when emergent, changing to olive green, dark green at maturity, 1–2 m (3.3–6.6 ft) long, 25–40 cm (10–16 in) wide. Median leaflets 13–26 cm (5.1–10 in) long, 13–22 mm (0.5–0.9 in) wide, otherwise as in subspecies *barteri.* FEMALE CONES very slightly longer and broader than in subspecies *barteri,* otherwise similar. MALE CONES very slightly longer and broader than in subspecies *barteri,* otherwise similar. HABITAT: Granite outcrops on steep hillsides in tropical woodland savanna consisting of scattered trees and a ground flora dominated by grasses, at elevations of 1220–1370 m (4000–4500 ft). DISTRIBUTION: Nigeria, Plateau state, known only from three colonies near the villages of Gilli and Tekkos on the Jos Plateau.

Encephalartos brevifoliolatus Vorster 1996b

PLATES 229, 230

The epithet for *Encephalartos brevifoliolatus* is derived from *brevi-,* Latin for short, and *foliolum,* leaflet, referring to the short leaflets. STEMS arborescent, erect or reclining, suckering from the base to form clumps of as many as six stems, to 2.5 m (8.2 ft) tall, 25–30 cm (10–12 in) in diameter, crown not woolly but the cataphylls initially covered with a thin, whitish tomentum. LEAVES numerous, rigid, straight or curved very slightly backward and downward toward the apex, 80–90 cm (32–35 in) long, and about 10–12 cm (4–4.7 in) wide. Petiole unarmed, at first covered with a fine white tomentum but glabrous at maturity, yellowish, 9–20 cm (3.5–8 in) long, 7–10 mm (0.3–0.4 in) in diameter. Leaflets angled forward 45°, opposing leaflets at an angle of about 135° to each other, producing a V-shaped cross section, dark green, narrowly ovate and somewhat falcate, lowest leaflets reduced in size but not to prickles, median leaflets overlapping in an upward direction, 6–8 cm (2.4–3.2 in) long, 10–12 mm (0.4–0.5 in) wide, spaced 8–10 mm (0.3–0.4 in) apart, the underside finely ribbed with 12–16 raised veins, margins entire and revolute. FEMALE CONES not described. MALE CONES as many as six per crown, erect, very narrowly ovoid, about 35 cm (14 in) long, 6–7 cm (2.4–2.8 in) in diameter when dry, covered with a fine white tomentum. Peduncle short, 25–33 mm (1–1.3 in) in diameter, the cone appearing sessile. Sporophylls 2.5–3 cm (1–1.2 in) long. Sporophyll face rhombic, 5–9 mm (0.2–0.4 in) high, 22–30 mm (0.9–1.2 in) wide, the facets not distinct except for the terminal facet, which is drawn out to about 5 mm (0.2 in), measuring 7–9 mm (0.3–0.4 in) high, 7–12 mm (0.3–0.5 in) wide. Sporangia in a single patch covering the underside of the sporophyll. HABITAT: Open grassland in full sun, or *Protea* savanna, sometimes on cliffs, in quartzite-derived sandstone soils, at elevations of 1300–1500 m (4300–4900 ft). DISTRIBUTION: South Africa, Northern province, known only from the Drakensberg escarpment.

Encephalartos brevifoliolatus was described as recently as 1996 from the Northern province, South Africa, based on only five widely scattered individuals, apparently the entire remaining population. An extensive search of the area by helicopter did not produce additional sightings.

All five individuals are males, which would indicate that this species is nearing complete extinction. I am aware of only one private collection with specimens of *E. brevifoliolatus,* no doubt collected as offsets from the known male plants.

The closest relative of *Encephalartos brevifoliolatus* is *E. laevifolius.* The two species share almost identical male cones, thin and unarmed petioles, densely white tomentose emergent leaves, and relatively narrow and entire leaflets that are finely ribbed on the underside. *Encephalartos brevifoliolatus* differs from *E. laevifolius* by its shorter, wider leaflets with their revolute margins.

There is no information available as to the cultivation of *Encephalartos brevifoliolatus,* but it is not expected that there should be any difficulty in growing it. Other species from the Northern province such as *E. eugene-maraisii* or *E. transvenosus* take quite well to cultivation, and *E. brevifoliolatus* should be no different.

Encephalartos brevifoliolatus is one of the most distinctive species of the genus, from an area that is well known for its varied and distinctive cycads. For this reason, from a collector's point of view, it is extremely desirable. This will no doubt cause a great deal of pressure to be brought about by illegal activities of private collectors and poachers. *Encephalartos brevifoliolatus* is thus considered extremely endangered; the plants are close to complete extinction. This cycad, because of its precarious conservation status, should be provided the strictest protection possible.

Encephalartos bubalinus Melville 1957

PLATES 231, 232

The epithet for *Encephalartos bubalinus* is Latin for buff, referring to the buff-colored tomentum covering the crown, cataphylls, and petiole bases. **Stems** arborescent, often suckering from the base, upright or with age leaning or decumbent, 1–2 m (3.3–6.6 ft) long, 33–45 cm (13–18 in) in diameter. Cataphylls densely buff tomentose on the lower surface. **Leaves** numerous, upright, oblanceolate in overall outline, 0.6–1.7 m (2–5.6 ft) long, 20–30 cm (8–12 in) wide, keeled, held in an erect crown. Petiole 1–2 cm (0.4–0.8 in) long, its base covered with fine, buff-colored tomentum. Leaflets in 50–90 pairs, angled forward 45°, reduced to spines above the petiole, median leaflets linear, rigid, leathery, 10–20 cm (4–8 in) long, 11–20 mm (0.4–0.8 in) wide, margins flat or very slightly revolute, the upper margin with two to four forwardly directed spiny teeth, the lower with none or one. **Female cones** solitary, ovoid, 32–45 cm (13–18 in) long, 24 cm (9.5 in) in diameter, green. Peduncle short, cone appearing sessile. Median sporophylls rhomboid, about 36 mm (1.4 in) high and 60 mm (2.4 in) wide, the facets distinct, their surface more or less smooth. Sarcotesta orange when ripe. Sclerotesta irregularly ovoid, 35–42 mm (1.4–1.7 in) long, 26–30 mm (1–1.2 in) in diameter, light tan, with 10–14 distinct longitudinal grooves of a slightly darker color. Chalaza 11–17 mm (0.4–0.7 in) in diameter and made of numerous irregular pits. **Male cones** one to five, ellipsoid to subcylindrical, often somewhat leaning, 27.5–55 cm (11–22 in) long, 13.8–15 cm (5.4–6 in) in diameter, green. Peduncle 9.5–12.5 cm (3.7–4.9 in) long, 3.5 cm (1.4 in) in diameter, smooth. Sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 7–15 mm (0.3–0.6 in) high, 20–25 mm (0.8–1 in) wide, the facets indistinct, the face slightly beaked, projecting 1–1.5 cm (0.4–0.6 in). Sporangia usually in a single somewhat heart-shaped patch, rarely with a secondary patch about 8 mm (0.3 in) in diameter on the upper front center of the sporophyll. **Habitat:** Open bushland on quartzite ridges, or montane forest with a few scattered trees, at elevations of 1300–2150 m (4300–7100 ft). Rainfall averages 1000 mm (40 in) annually, falling mostly in summer. The climate is hot in summer, cool in winter. **Distribution:** Tanzania, Masai district, between Loliondo and Lake Natron.

Peter René Oscar Bally, a Swiss botanist who lived in Kenya and was noted for his work on the succulents of East Africa, discovered *Encephalartos bubalinus* on September 17, 1944. Material from his collection was subsequently sent to Ronald Melville, a taxonomist at the Royal Botanic Gardens Kew, England, who was working on *Encephalartos* for the *Flora of Tropical East Africa.* Melville recognized the specimen as undescribed and described it in 1957. Because of the remote habitat of the cycad, few specimens have ever reached botanical gardens or private collectors. Two paragraphs from a letter dated July 27, 1969, that I received from W. Carmichael of Arusha, Tanzania, are of interest:

> On my recent safari I was able to get good photographs at a place called Kiswisawis only seven miles [11 km] from Loliondo and some others farther along this new road to DigoDigo in the Sonjo Valley. The plants growing at Kiswisawis were at 7000 ft. [2100 m] and down at Tinaga at 5600 ft. [1700 m] These were growing in the *Combretum / Commiphora / Acacia* vegetation type. The plants at 7000 ft. are of course in the montane forest area. The *Encephalartos* are found

> in the open grass and shrub areas where there are out-cropping rocks and only a few scattered trees.
>
> I am enclosing a photograph of young cones which have already formed and at the same place there were other seed ripe, the aril having been removed by Baboons and Hyrax. It would appear that the seeds take about 8–12 months to ripen. The Sonjo lad who appears in the photographs tells me that the Sonjo people eat the kernel, but I asked him to confirm this and let me know later. I tasted one and found it quite pleasant. . . . The seed appears to be ripe in April & May.

Encephalartos bubalinus grows well in cultivation and I consider it to be one of the more rapidly growing species. Plants with grapefruit-sized stems can be produced from seed in 6–8 years. Even though *E. bubalinus* is from a relatively high elevation in some places, it does not seem to have much frost tolerance. I have had plants defoliate on several occasions as a result of frost, but as soon as warm weather returned they generally produced new leaves. This species should only be considered for warm temperate to tropical climates, or grown with the proper protection.

Encephalartos bubalinus, as true of several of the central African cycads, is from a remote habitat, protecting it from all but the most determined collectors. All reports indicate that the species is relatively common within its distributional range, and regeneration is reported to be good. Although the Sonjo people are known to eat seeds, apparently they are only consumed during times of famine or crop failure. *Encephalartos bubalinus* is considered not threatened.

Encephalartos caffer (Thunberg) Lehmann 1834

PAGES 2–3, PLATES 233, 234

Cycas caffra Thunberg 1775, *Zamia caffra* (Thunberg) Thunberg 1800

Encephalartos brachyphyllus Lehmann & de Vriese in de Vriese 1838

The epithet for *Encephalartos caffer* refers to Caffraria, a region in the Eastern Cape province, South Africa. **Stems** subterranean, solitary or branched from the base, to 30 cm (12 in) long, 15–25 cm (6–10 in) in diameter, crown woolly, roots thick, tuberous, and contractile. **Leaves** about 7–10 in mature plants, erect to spreading, light green, straight or slightly twisted, 40–90 cm (16–36 in) long, 9 cm (3.6 in) wide, slightly keeled, brown tomentose in the juvenile stage, the tomentum soon weathering away. Petiole 6–12 cm (2.4–4.7 in) long, 6–8 mm (0.2–0.3 in) in diameter. Leaflets lanceolate, crowded, twisted irregularly from the axis, gradually reduced toward the base and eventually ending in one or two prickles, median leaflets 8–10 cm (3.2–4 in) long, 8–10 mm (0.3–0.4 in) wide, margins entire in mature plants, juvenile plants sometimes with one or two teeth on both margins. **Female cones** solitary, subcylindrical, 20–30 cm (8–12 in) long, 12–15 cm (4.7–6 in) in diameter, slightly narrowed toward the apex and base, greenish yellow. Peduncle 4–7 cm (1.6–2.8 in) long, 3–3.5 cm (1.2–1.4 in) in diameter. Sporophylls flattened, about 5.5 cm (2.2 in) long, with a large terminal facet. Sporophyll face about 3.5 cm (1.4 in) high and 5.5 cm (2.2 in) wide, lower margins somewhat projected and irregularly toothed. Sarcotesta bright red to scarlet when ripe. Sclerotesta 25–31 mm (1–1.2 in) long, 18–23 mm (0.7–0.9 in) in diameter, smooth except for 10–12 indistinct longitudinal grooves. **Male cones** solitary, subcylindrical, 20–30 cm (8–12 in) long, 6–11 cm (2.4–4.3 in) in diameter, narrowed toward the apex, greenish yellow. Peduncle erect, 6–8 cm (2.4–3.2 in) long, 1–1.5 cm (0.4–0.6 in) in diameter, glabrous. Sporophyll face triangular, 10–15 mm (0.4–0.6 in) high, 17–24 mm (0.7–0.9 in) wide, light green, glabrous, more or less smooth, projected into a beak about 5 mm (0.2 in) long, lower margin sometimes serrate. Sporangia in one patch covering the entire underside of the sporophyll. **Habitat:** Grassland in the coastal belt. Summer rainfall varies from 1000 mm (40 in) along the coast to considerably less inland. Summer temperatures are hot, and frost in winter is infrequent. **Distribution:** South Africa, Eastern Cape province, Alexandria, Bathurst, East London, Humansdorp, and Kentani districts.

Encephalartos caffer and *E. longifolius* were the first two South African cycads to be discovered. Carl Peter Thunberg and Francis Masson originally collected them during a botanical expedition to the eastern Cape province in 1772. At the time, *E. caffer* was mistakenly thought to be a seedling of *E. longifolius,* which occurred in the same vicinity. It was not until much later that this confusion was clarified and the names *E. caffer* and *E. longifolius* properly applied. *Encephalartos caffer* holds the distinction of being the southernmost cycad species in Africa.

Encephalartos caffer is a relatively rare, dwarf, subterranean stemmed cycad that grows in grassland. Its contractile roots pull the stem into the ground, and its short leaves are usually lost to view among the grass in which it grows. Annual grass fires generally defoliate this little cycad, but its subterranean stem protects the plant from any major damage, and new leaves are produced with the spring rains.

Even though *Encephalartos caffer* is an interesting cycad, it is not generally well represented in botanical gardens and private collections because of the difficulty in obtaining plants. Seed is seldom available, but when it is, it usually exhibits a high percentage of fertility. Seedlings grow reasonably fast and soon produce miniature replicas of the adult plants. Mature specimens transplant easily but often take a considerable period of time to reestablish. This species grows well in cultivation and prefers full sun for best results.

Until relatively recently, *Encephalartos caffer* was thought to be on the brink of extinction and was one of the first Cape species to be declared endangered. Only a handful of plants were known in the wild, and the species was equally rare in cultivation. Then one day a call was received by a government agricultural advisor, regarding a problem a local farmer was having. He said one of his fields was infested with a "bulb plant" that was breaking his plow and he wanted to know how to kill it. When the advisor made a trip to the farm and found a field full of *E. caffer,* it made the news! Subsequently, a rocky section of the farmer's land was expropriated and made into a preserve for the conservation of *E. caffer.* It is hoped that seed will be produced there that will multiply the numbers of this species in cultivation.

Encephalartos cerinus Lavranos & D. L. Goode 1989

PLATES 235–237

The epithet for *Encephalartos cerinus* is derived from *cereus,* Latin for waxy, referring to the waxy coating of the leaves and cones. STEMS subterranean or slightly exposed when growing in rock, sometimes branching from the base, to 30 cm (12 in) long, 20–25 cm (8–10 in) in diameter, crown slightly woolly. LEAVES usually 8–15, rarely as many as 20, upright, straight, rigid, elliptical, glaucous green with a waxy coating, 0.9–1.2 m (3–3.9 ft) long, 20–24 cm (8–9.4 in) wide, flat. Petiole unarmed, round, smooth, 12–18 cm (4.7–7.1 in) long, 13 mm (0.5 in) in diameter. Leaflets slightly overlapping in the upper half of the leaf and directed toward the apex, reduced in length toward the base and apex, the last two or three basal leaflet pairs abruptly becoming spiny, median leaflets 15–18 cm (6–7.1 in) long, 12 mm (0.5 in) wide, tapering toward both ends but unequally, margins entire in adults, with none to three short spines on the lower margin of seedling or juvenile leaflets. FEMALE CONES solitary, erect, obovoid, 30–35 cm (12–14 in) long, 15–18 cm (6–7.1 in) in diameter, tapering toward the apex, glaucous green, becoming yellow-orange at maturity except in shaded locations. Peduncle short, hidden among the cataphylls, the cone appearing sessile. Sporophyll face smooth, 2–2.5 cm (0.8–1 in) high, 4.5–5 cm (1.8–2 in) wide, the terminal facet slightly concave, the lower edge armed with irregularly lobed teeth 3–5 mm (to 0.2 in) long and directed downward. Sarcotesta deep pink to red when ripe. Sclerotesta unequally elliptical, 21–27 mm (0.8–1.1 in) long, 16–19 mm (0.6–0.7 in) in diameter, the surface between the 9–13 longitudinal ridges delicately traced with a network of irregular grooves. Chalaza 5–8 mm (0.2–0.3 in) in diameter, somewhat flattened. MALE CONES solitary, subcylindrical, erect, 55–60 cm (22–24 in) long, 8–10 cm (3.2–4 in) in diameter, glaucous green, turning yellow-orange at maturity. Peduncle about 80 mm (3.2 in) long and 22 mm (0.9 in) in diameter. Sporophylls with a flattened terminal facet, the lateral ridge not extending beyond the terminal facet, lower margin with occasional small rounded teeth directed downward. Sporophyll face 15–18 mm (0.6–0.7 in) high, 20–25 mm (0.8–1 in) wide, the facets indistinct. Sporangia in a single patch covering the lower surface of the sporophyll. HABITAT: Rocky river gorge, on sheer sandstone cliffs in rock crevices and among boulders, occasionally close to the water's edge. The conditions are generally hot and dry, with the elevation of occurrence about 900 m (3000 ft). DISTRIBUTION: South Africa, KwaZulu-Natal province, Tugela Ferry district.

Encephalartos cerinus was described in 1989, some 20 years after its discovery by Reinwald Dedekind, a farmer in the Tugela Ferry district of KwaZulu-Natal who saw one growing in a neighbor's garden and recognized it as being different. Only two small colonies of this interesting cycad have been found, the first located in 1970 and consisting of about 12 plants. Plant poachers removed the cycads from the original colony shortly after it was discovered. The second colony was located in 1987 and contained about 200 adult plants, and numerous seedlings and juvenile plants. Reports indicate that this colony has also been completely removed. It is sad that a few people interested only in monetary gain can bring a rare and beautiful cycad to the brink of extinction. It would be far better to harvest the seed produced by the plants in habitat so that the species could be made available to many collectors and institutions, thereby reducing the pressure on the wild populations.

The closest relatives of *Encephalartos cerinus* appear to be *E. ngoyanus, E. umbeluziensis,* and *E. villosus. Encephalartos cerinus* differs from *E. ngoyanus* by its longer, upright, gray-green leaves and thick, stiff leaflets, from *E. umbeluziensis* by its shorter gray-green leaves, leaflets with entire margins, solitary orange to yellow cones with a waxy bloom, and overlapping, fringed, female sporophylls and from *E. villosus* by its much shorter gray-green leaves with bare petioles.

In cultivation, *Encephalartos cerinus* is a hardy, relatively fast growing and beautiful cycad. The one large specimen in my collection grew from seed to grapefruit size in just 7 years. It maintains about 20 upright gray-green leaves and is a lovely sight to see. It is considered by some South African growers as one of the strongest growing species of *Encephalartos,* an opinion with which I strongly agree. In my limited experience, *E. cerinus* has shown itself to be hardy to slightly below freezing for short periods of time. Its small size and erect grayish leaves make *E. cerinus* a fine garden or pot plant.

The conservation information available leads us to believe that *Encephalartos cerinus* may be nearing extinction in the wild. The area in which the two colonies were found is not well explored, and it is possible that more may be located. Until additional colonies are located, *E. cerinus* must be considered extremely endangered.

Encephalartos chimanimaniensis R. A. Dyer & I. C. Verdoorn 1969

PLATES 238–240

The epithet for *Encephalartos chimanimaniensis* refers to the Chimanimani Range that run along the border between Zimbabwe and Mozambique, where this cycad was discovered. **Stems** arborescent, erect, stout, suckering from the base, rarely branched, to 1.8 m (5.9 ft) tall, 45 cm (18 in) in diameter, crown densely packed with woolly gray cataphylls. **Leaves** numerous, erect, about 1.5 m (4.9 ft) long, 30–40 cm (12–16 in) wide, oblong elliptical, juvenile foliage woolly but soon glabrescent. Petiole 2–6 cm (0.8–2.4 in) long. Rachis almost straight or slightly arching in the upper half. Leaflets glossy green, inserted 2–3.5 cm (0.8–1.4 in) apart in an open venetian-blind position and overlapping in a downward direction, reduced to prickles toward the base, median leaflets slightly falcate, 15–20 cm (6–8 in) long, 1.8–3 cm (0.7–1.2 in) wide, often with two to four small spines toward the base of the upper and lower margins, the apical spine sometimes hooked. **Female cones** solitary, erect, barrel shaped, 45–50 cm (18–20 in) long, 18–20 cm (7.1–8 in) in diameter, greenish blue. Peduncle 7–8 cm (2.8–3.2 in) long but the cone generally appearing sessile. Sporophylls 5.5–6 cm (2.2–2.4 in) long. Sporophyll face 28–33 mm (1.1–1.3 in) high, 60–70 mm (2.4–2.8 in) wide, with distinct facets, the facet surface generally smooth. Sarcotesta red when ripe. Sclerotesta 27–32 mm (1.1–1.3 in) long, 17–23 mm (0.7–0.9 in) in diameter, generally smooth except for 7–12 shallow, indistinct, longitudinal grooves. **Male cones** one to three, erect, subcylindrical, 50–70 cm (20–28 in) long, 8–11 cm (3.2–4.3 in) in diameter, narrowed gradually toward the apex and base. Peduncle 10–15 cm (4–6 in) long. Sporophylls 3–4.5 cm (1.2–1.8 in) long. Sporophyll face 25–30 mm (1–1.2 in) high, 28–35 mm (1.1–1.4 in) wide, somewhat resembling a tortoise head, the upper facet strongly humped with two receding ridges, the terminal facet together with the lower facet appearing beaklike in side view. Sporangia in a single irregular patch covering the entire undersurface of the sporophyll except for a sterile margin 2–3 mm wide. **Habitat:** Steep slopes in sparse grass and shrub growth at elevations of 1000–1300 m (3300–4300 ft). Rainfall averages 1600–2000 mm (63–79 in) annually and may fall at any time of the year. Temperatures are 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Zimbabwe and Mozambique, known only from the Chimanimani Range.

Until 1969, *Encephalartos chimanimaniensis* was included in the complex of plants then known as *E. manikensis.* In their 1969 revision of the *E. manikensis* complex, Robert Allen Dyer and Inez Clare Verdoorn described four new species from this complex, one of which was *E. chimanimaniensis.*

Encephalartos chimanimaniensis has always been a rare plant and therefore is not encountered in many collections. Its habitat is remote and of difficult access, and the plants are so scarce that the chance of locating them is almost a matter of luck. In 1965 I spent 2 days on foot in the Chimanimani Range looking for this cycad without ever sighting one. The habitat is very difficult to traverse because of the many steep-sided rocky canyons and vertical cliffs. The terrain is quite scenic, and many panoramic views of Mozambique can be had from the high points on the Zimbabwe side.

In cultivation, *Encephalartos chimanimaniensis* does not present many problems and seems to be moderately frost hardy and of reasonably rapid growth. The specimens I observed in the garden of the late Raymond Munch of Rusape, Zimbabwe, were robust, carried numerous leaves, and produced cones regularly. Munch's plants had many basal offsets, completely ringing the stems. The leaves were upright, broad, and held the leaflets in a half open venetian-blind effect.

Encephalartos chimanimaniensis is one of the most endangered of the central African species of *Encephalartos.* It has a very restricted distribution in the Chimanimani Range, and few specimens survive in habitat. An isolated clump of two plants reported in 1965 from Zimbabwe was soon poached by collectors. No wild specimens are known to remain in Zimbabwe; the few surviving specimens reported are from one locality in Mozambique. *Encephalartos chimanimaniensis* must be considered extremely endangered and in peril of becoming extinct in the wild.

Encephalartos concinnus R. A. Dyer & I. C. Verdoorn 1969

PAGES 2–3 , PLATES 241, 242

The epithet for *Encephalartos concinnus* is Latin for neat, pretty, or elegant, used by Robert Allen Dyer and Inez Clare Verdoorn in reference to the male cones but it could have been equally well chosen in describing the entire plant. **Stems** arborescent, erect though larger stems usually leaning or decumbent, usually suckering from the base though rarely not suckering and juvenile specimens usually solitary, to 2.5 m (8.2 ft) long, 35–45 cm (14–18 in) in diameter. Cataphylls woolly. **Leaves** numerous, oblong, rounded at the apex, gradually narrowed toward the base, 1.5–2 m (4.9–6.6 ft) long, 20–30 cm (8–12 in) wide, slightly keeled. Petiole 6–10 cm (2.4–3.9 in) long and about 1 cm (0.4 in) in diameter. Rachis subterete, tomentose when young, glabrous with age except for its base. Leaflets usually about 50 pairs, lanceolate, inserted 1–1.5 cm (0.4–0.6 in) apart, spreading, basal leaflets reduced to prickles, median leaflets 10–15 cm (4–6 in) long, 2–2.3 cm (0.8–0.9 in) wide, straight or slightly curved upward toward the apex, in half-open to nearly closed venetian-blind disposition and overlapping in a downward direction, margins with one to three spines or more near the base on the upper and lower sides, apical spine present. **Female cones** solitary, erect, subcylindrical, 35–45 cm (14–18 in) long, 15–20 cm (6–8 in) in diameter, narrowed slightly toward the apex, green. Peduncle 6–8 cm (2.4–3.2 in) long and in diameter. Median sporophylls 3 cm (1.2 in) tall, 5–5.5 cm (2–2.2 in) wide. Sporophyll face projecting about 2 cm (0.8 in), the surface slightly granular or wrinkled and glabrous. Sarcotesta red when ripe. Sclerotesta smooth, 25–30 mm (1–1.2 in) long, 15–22 mm (0.6–0.9 in) in diameter, light brown or tan, with 15–17 shallow longitudinal grooves generally made prominent by their darker color. **Male cones** one to four, erect, narrowly ovoid to subcylindrical, 30–50 cm (12–20 in) long, 7.5–10 cm (3–4 in) in diameter, green. Peduncle 5–12 cm (2–4.7 in) long. Sporophyll face 7–13 mm (0.3–0.5 in) high, 17–23 mm (0.7–0.9 in) wide, projecting 7–10 mm (0.3–0.4 in). Sporangia in a single patch covering the entire underside of the sporophyll. **Habitat:** Generally dry steep-sided rocky valleys with scattered trees, among granite boulders (Mberengwa, Zimbabwe) or on cliffs near the crests of steep granite hillsides or among grass or under small trees (Runde and West Nicholson), at elevations of 800–900 m (2600–3000 ft). Rainfall averages 300–500 mm (12–20 in) annually, falling mainly in summer. All habitat areas are subject to frequent night and early morning mists. **Distribution:** Zimbabwe, in Gwanda, Mberengwa (Belingwe), and Runde (Lundi) districts, most common in the Mberengwa Tribal Trust Land where large numbers of plants occur, scattered and scarce in the areas of West Nicholson, Gwanda district, and on a thickly wooded granite hill near the Runde Bridge, Runde district. Mozambique, reported to occur between Chimoio (Vila Pery) and Vila Gouveia.

Encephalartos concinnus was described in 1969 when Robert Allen Dyer and Inez Clare Verdoorn separated it from the *E. manikensis* complex. *Encephalartos concinnus* as well as the other three species newly named from this group were based primarily on differences in the male cones. Without male cone material, the identification of these species can be quite difficult, except in the case of *E. munchii,* which has very distinctive leaves. These five species have fairly well defined distribution limits and can therefore usually be identified if one possesses good collection data.

The Mberengwa habitat of *Encephalartos concinnus* is picturesque, with its huge granite boulders and scattered trees. The cycads are striking in appearance, with their dark green fronds against the lighter background. This species is one of the few that grow as well in habitat as in cultivation, the individual plants maintaining large numbers of leaves. This could also be the result of sparse vegetation in their area, protecting them from fire disturbance. Rainfall is sparse but heavy mists are frequent, condensing on the leaves and dripping around the base of the plants, thereby providing additional moisture.

Encephalartos concinnus is not common in collections even though it is a handsome cycad. This is no doubt the result of its small populations, remote habitats, and lack of seedling availability. It does well in cultivation, though in my experience it is not particularly fast growing. In cultivation, a sunny location and good drainage are required for healthy growth.

The conservation status of *Encephalartos concinnus* is unclear. The total number of plants in the three populations accepted as *E. concinnus* probably number about 200. The small size of the entire population would necessitate classifying this species as vulnerable. Considerable differences in leaf morphology have been noted in the three disjunct populations of *E. concinnus.* If additional investigation discloses specific differences in the cones and the colonies are found to be distinct species, the status would have to be reevaluated and the plants would have to be judged as at greater risk.

Encephalartos cupidus R. A. Dyer 1971

PLATES 243–245

The epithet for *Encephalartos cupidus* is Latin for desirous, and quoting Robert Allen Dyer's translation, "implying a passionate desire, to the extent of greed or lust," giving a clear indication of his feeling toward the illegal collection of these plants from their habitat. **Stems** unbranched, usually subterranean and suckering from the base but rarely growing to 2.7 m (8.9 ft) long, 20–30 cm (8–12 in) in diameter, the exterior covered with an alternating series of leaf bases and cataphylls. Cataphylls about 5 cm (2 in) long, lanceolate, acuminate, whitish woolly on the outer surface. **Leaves** usually 7–10, straight, glaucous green, spreading, 0.7–1 m (2.3–3.3 ft) long, 25–30 cm (10–12 in) wide, moderately keeled, apex slightly upturned, emergent leaves lightly tomentose but soon glabrous. Petiole 4–8 cm (1.6–3.2 in) long, 1 cm (0.4 in) in diameter. Leaflets crowded in the upper half of the leaf, inserted about 3 cm (1.2 in) apart toward the base, sometimes reduced to two or three prickles at the base, median leaflets linear lanceolate, straight, stiff, 10–15 cm (4–6 in) long, 1–1.3 cm (0.4–0.5 in) wide, the upper and lower margins with two to five forward-directed sharp prickles 4–7 mm (to 0.3 in) long, apex terminating in a single prickle. **Female cones** solitary, rarely in pairs, ovoid, 20–30 cm (8–12 in) long, 15–20 cm (6–8 in) in diameter, glabrous, bright apple green, sometimes turning somewhat apricot when mature. Peduncle to 6 cm (2.4 in) long but hidden in the cataphylls, the cone appearing sessile. Median sporophylls 2.5–3.5 cm (1–1.4 in) high, 4.5–5.5 cm (1.8–2.2 in) wide, the terminal facet about 8 mm (0.3 in) high and 13 mm (0.5 in) wide, sunken so as to appear pitlike, the upper and lower lateral facets essentially smooth but slightly wrinkled around the margins of the terminal facet, the outside margins of the sporophyll somewhat tuberculate above and below. Sarcotesta apricot colored when ripe, unlike most other species easily and cleanly removed from the sclerotesta. Sclerotesta somewhat ovoid, 28–32 mm (1.1–1.3 in) long, 19–25 mm (0.8–1 in) wide, smooth except for 9–10 indistinct longitudinal grooves. **Male cones** solitary, erect, subcylindrical, 18–32 cm (7.1–13 in) long, 5–8 cm (2–3.2 in) in diameter, bright apple green. Peduncle 3.5–10 cm (1.4–3.9 in) long, 3.5–4 cm (1.4–1.6 in) in diameter, glabrous. Sporophylls about 3 cm (1.2 in) long. Sporophyll face 6–13 mm (0.2–0.5 in) high, 17–23 mm (0.7–0.9 in) wide, projecting 5–7 mm (0.2–0.3 in), glabrous, the terminal facet somewhat sunken, lateral and medial facets not well defined. Sporangia covering the lower side of the sporophyll, extending to the outside margins and to within 3–5 mm (to 0.2 in) of the terminal facet. **Habitat:** Open rocky grassland with scattered trees, usually between boulders or on cliffs, rarely in boulder-strewn grassland, seeming to prefer dolomite-based soil. Rainfall is 350–750 mm (14–30 in) annually, falling mainly in summer. The habitat is generally dry with frequent droughts and fires. **Distribution:** South Africa, Mpumalanga province, restricted to Lydenburg and Pilgrims Rest districts, generally in the catchment area of the Blyde River.

I first learned of the plant that was to be described as *Encephalartos cupidus* in 1969 when a correspondent informed me of a "new" form of *E. eugene-maraisii* from the Blyde River area of the Transvaal province (now in Mpumalanga), South Africa. At the time, a leaf from this plant was sent to Robert Allen Dyer of the Division of Botany in Pretoria. The leaf had been obtained from the garden of David van Heerden of White River, and he had collected the plant from the farm, Steenveld, in the Lydenburg district. With the help of van Heerden and the Department of Nature Conservation, sufficient material was collected so that Dyer was able to describe *E. cupidus* in 1971.

Encephalartos cupidus is a very decorative cycad of small stature. Because of its rarity it is not often encountered in botanical gardens or private collections. It adapts well to cultivation, and single-stemmed specimens will form sizable clumps in just a few years through the production of basal offsets. Seed seems difficult to obtain, so it would appear that the primary form of propagation will have to be by offsets. Besides well-drained soil, *E. cupidus* prefers full sun for best growth and development.

Encephalartos cupidus occurs in the Blyde River Nature Reserve, where it is protected. Regeneration in habitat does not seem rapid. Because of the limited habitat and the rarity of the plants, this species must be considered extremely endangered. In more recent years, the staff of the Lowveld National Botanical Garden, Nelspruit, has planted colonies of native species of *Encephalartos* in what they refer to as seed orchards. These seed orchards comprise 15–25 plants of each species, grown with the hope of producing viable seed. One of the species that has already produced seed is *E. cupidus.* With proper management of this breeding stock, *E. cupidus* and several other extremely endangered species of South African cycads may have their numbers multiplied within a very few years.

Encephalartos cycadifolius (Jacquin) Lehmann 1834

PLATES 246, 247

Zamia cycadifolia Jacquin 1801, not Thiselton-Dyer 1883b (see *Z. loddigesii*)

Encephalartos eximius I. C. Verdoorn 1954

The epithet for *Encephalartos cycadifolius* is derived from the name of the most well known cycad of the early nineteenth century, *Cycas revoluta,* and *folium,* Latin for leaf, alluding to the resemblance between the two species. **Stems** usually subterranean, rarely arborescent, suckering freely from the base to form clumps of as many as 20 or more stems, 1–1.5 m (3.3–4.9 ft) long, 25–30 cm (10–12 in) in diameter. **Leaves** numerous, 60–90 cm (24–36 in) long, 17.5 cm (6.9 in) wide, somewhat woolly in the juvenile stage, glabrous with age, shallowly keeled, curved inward and usually somewhat twisted. Petiole unarmed, 9–20 cm (3.5–8 in) long, 7–10 mm (0.3–0.4 in) in diameter. Rachis slightly yellow with age. Leaflets dark olive green, 9–12 cm (3.5–4.7 in) long, 4–6 mm (0.2 in) wide, the underside with five or six prominent veins, margin entire, slightly revolute, thickened. **Female cones** one or two, barrel shaped, 20–30 cm (8–12 in) long, 16–18 cm (6.3–7.1 in) in diameter, covered with an off-white or tawny tomentum. Peduncle short, cone appearing sessile. Sporophylls 4–4.5 cm (1.6–1.8 in) long. Sporophyll face flattened, 2.5–3 cm (1–1.2 in) high, 4–4.5 cm (1.6–1.8 in) wide, densely tomentose, the terminal facet sunken, other facets indistinct. Sarcotesta orange-yellow to amber brown when ripe. Sclerotesta irregularly ovoid, somewhat three-sided, 22–29 mm (0.9–1.1 in) long, 17–19 mm (0.7 in) in diameter, light brown, with 8–14 indistinct shallow longitudinal grooves. **Male cones** one or two, more or less cylindrical, 13–22 cm (5.1–8.7 in) long, 4.5–7 cm (1.8–2.8 in) in diameter, narrowing toward the apex, covered with short gray-white tomentum. Peduncle short, cone appearing sessile. Median sporophylls about 2 cm (0.8 in) long. Sporophyll face 10–13 mm (0.4–0.5 in) high, 18–24 mm (0.7–0.9 in) wide, only slightly projecting. Sporangia in a single irregular patch. **Habitat:** Barren grassland at elevations up to 1800 m (5900 ft). Rainfall is 625–800 mm (25–32 in) annually, falling mainly in summer. Winters are cold with frequent frosts and snow, the temperatures sometimes as low as −6°C (21°F). **Distribution:** South Africa, Eastern Cape province, Bedford and Cradock districts, restricted to the Winterberg.

In 1799 a Viennese collector and gardener named Georg Scholl, while in South Africa, collected specimens of three cycads. Scholl took these specimens back to Vienna for cultivation at the Royal Garden at Schönbrunn. One of these plants was studied by the noted botanist Nicolaus Joseph von Jacquin, who in 1801 illustrated and described it as *Zamia cycadifolia.* The specific name *cycadifolia* was picked because Jacquin thought the leaves resembled those of *Cycas revoluta.* Then in 1834 another famous botanist, Johann Georg Christian Lehmann, described the genus *Encephalartos* and transferred Jacquin's *Zamia cycadifolia* into it. The correct name then became *E. cycadifolius.* At the same time Lehmann transferred that species into *Encephalartos,* he described a new species, *E. friderici-guilielmi.* Several botanists disagreed with Lehmann's concept of *E. friderici-guilielmi* and felt it was the same as *E. cycadifolius,* and the name *E. friderici-guilielmi* fell into disuse. Another complication was introduced in 1954 when Inez Clare Verdoorn described *E. eximius* (which was in fact the newly rediscovered *E. cycadifolius*) from the Winterberg. Finally, Robert Allen Dyer (1965b) cleared up this taxonomic entanglement when he proved that *E. cycadifolius* and *E. friderici-guilielmi* were distinct species and placed *E. eximius* into synonymy under *E. cycadifolius.*

Encephalartos cycadifolius is most closely related to *E. friderici-guilielmi* and *E. ghellinckii,* all three species from similar habitats. *Encephalartos cycadifolius* most closely resembles *E. ghellinckii* in habit. Both have bowl-shaped crowns of leaves and narrow leaflets but the two can be distinguished. *Encephalartos cycadifolius* has no wool in its crown, its leaflets are broader, its leaflet margins are thickened but only slightly revolute, its leaves have a twist, giving them a somewhat untidy appearance, and its stems are short and form large clumps. In *E. ghellinckii* there is copious wool in the crown, the leaflets are not more than 4 mm wide, margins are strongly revolute, leaves are evenly and regularly bent inward, and stems are tall, upright, seldom forming offsets. *Encephalartos friderici-guilielmi* may be separated from *E. cycadifolius* by its woolly crown, longer leaflets with flat margins, straight leaves that are generally held horizontally, and tall, arborescent stem.

Encephalartos cycadifolius is an interesting cycad that is rare in cultivation. It is extremely difficult to transplant. Stems have been known to take as long as 5 years or more to reestablish, with many plants not surviving relocation. This cycad grows best in well-drained alkaline soil and full sun. It is quite frost hardy in temperate climates. Seed of *E. cycadifolius* is rarely collected, therefore seedlings are not often available. It appears that a fire symbiosis exists, and heavy cone production usually follows the plant's being burned over. The following account by Mr. V. L. Pringle of Bedford, Eastern Cape, written to Dyer, is of interest:

> I have been very interested this season in the behavior of the Cycads [*E. cycadifolius*] which grow in these mountains. In August last year I burnt down some stretches in the mountain which had become overgrown with coarse grass and all the Cycads, of which there are hundreds, had their leaves burnt off. They soon came out in full leaf and are now looking better than ever before—and there is scarcely one in hundreds which has not fruited. I notice that where others grow, which were not burnt, there is no sign of any fruit as yet. The good rains at the end of July might have helped them but is has been dry through September-October-November. The only explanation that I can see is that the burning has stimulated the plants.

Stimulation by fire is known in several other genera of cycads, and fire plays a major role in forcing the production of new leaves as well as cleaning out the undergrowth of brush and grass.

During winter, the habitat of *Encephalartos cycadifolius* experiences considerable frost and frequent snowfalls. This cycad has adapted to these conditions by the bowl-shaped formation of the leaves, which allows the snow to fall through the leaf crown, preventing mechanical damage from the weight of snow accumulation.

The conservation status of *Encephalartos cycadifolius* is far better than most of the other species of the genus. In a 1995 survey, more than 10,000 mature plants were counted in the wild, not including all known colonies. Seedling recruitment is very low in all the colonies that have been studied, but for this cycad, which forms large clumps and thus lives a very long time, that is not a critical factor. For these reasons, *E. cycadifolius* must be considered not threatened.

Encephalartos delucanus Malaisse, Sclavo & Crosiers 1992

PLATES 248, 249

Encephalartos delucanus is named in honor of Paulo De Luca (b. 1944), professor of botany and director of the botanical gardens at the University of Naples, Italy, who is well known for his research on cycads. **Stems** mainly subterranean but sometimes producing an arborescent stem to about 12 cm (4.7 in) tall, 10–20 cm (4–8 in) in diameter. Cataphylls lanceolate, 3–4 cm (1.2–1.6 in) long, 1 cm (0.4 in) wide, the lower surface densely gray-brown tomentose, the upper surface brown and glabrous. **Leaves** usually six to nine, green, 50–65 cm (20–26 in) long, oblong but rapidly narrowing toward the base, strongly keeled and distinctly curved backward and downward at the apex. Petiole about 45 mm (1.8 in) long, 7–8 mm (0.3 in) in diameter, base with a persistent tomentum of gray-beige hairs about 3–4 mm long and brown-black hairs 1 mm long, the upper side marked by two parallel dark green lines. Leaflets in 25–35 pairs, overlapping in a downward progression, rapidly reduced to spines at the base, median leaflets oblong, 13–14.6 cm (5.1–5.7 in) long, 12–14 mm (0.5–0.6 in) wide, gradually acuminate toward the apex, margins with yellowish spines 4–5 mm (0.2 in) long, with two or three on the upper margin, three or four on the lower, the apical spine 2–4 mm long. **Female cones** not described. **Male cones** usually one or two, ellipsoid to subcylindrical, 10–12 cm (4–4.7 in) long, 2–3 cm (0.8–1.2 in) in diameter, green when mature. Peduncle 10–15 mm (0.4–0.6 in) long, about 8 mm (0.3 in) in diameter when dry. Median sporophylls 12–14 mm (0.5–0.6 in) long, 9–11 mm (0.4 in) wide, inclined 60–70°. Sporophyll face with the upper facet concave, the terminal facet rhomboid, the lateral facets trapezoidal, the median facet rectangular, and with an indistinct median crest. Sporangia in a single irregular patch. **Habitat:** Wooded savanna at elevations of 1500–1950 m (4900–6400 ft). **Distribution:** Tanzania, Western province, Mapanda district, near the village of Mgoga, located about 30 km (19 miles) south of Katambike on the south side of the Uqulla River.

Encephalartos delucanus (Tanzania) is one of a group of small-stemmed species, also comprising *E. marunguensis* (Democratic Republic of the Congo), *E. poggei* (Congo, Angola), and *E. schmitzii* (Congo, Zambia). All four, with the possible exceptions of *E. poggei* and *E. schmitzii,* seem to be quite rare and of irregular occurrence.

Few, if any, specimens of *Encephalartos delucanus* are in cultivation. This cycad should not pose a problem in cultivation, as its relatives are easily grown. The group is not cold tolerant and should be protected at all times from freezing weather.

Encephalartos delucanus must be considered extremely endangered. Investigations have thus far shown *E. delucanus* to be very rare in habitat, and no regeneration has been observed.

Encephalartos dolomiticus Lavranos & D. L. Goode 1988

PLATES 250, 251

Encephalartos verrucosus Vorster, Robbertse & S. van der Westhuizen 1988b

The epithet for *Encephalartos dolomiticus* refers to this cycad's habitat on dolomite outcrops. STEMS arborescent, usually unbranched but suckering from the base to form clumps, erect or in older specimens sometimes procumbent, to 2 m (6.6 ft) long, 25–40 cm (10–16 in) in diameter. Cataphylls buff colored, 3–6 cm (1.2–2.4 in) long, the outside with a covering of persistent tomentum. LEAVES numerous, glaucous, more or less straight but twisted along the axis of the rachis, giving a somewhat untidy appearance, 60–80 cm (24–32 in) long, 15 cm (6 in) wide. Petiole 10–12 cm (4–4.7 in) long, swollen at the base where it is covered by a dense, light brown tomentum. Leaflets angled forward about 45°, basal leaflets not crowded, flatly inserted into the rachis, those of the apical half crowded and overlapping in an upward direction, strongly keeled, median leaflets 12–17 cm (4.7–6.7 in) long, 1–1.2 cm (0.4–0.5 in) wide, narrowly elliptical and somewhat falcate, tapering toward both ends, apex pungent, apical and basal leaflets slightly reduced in length, margins entire or rarely with one or two teeth on the lower side only. FEMALE CONES solitary, rarely as many as three (?), ovoid, 30–45 cm (12–18 in) long, 18–25 cm (7.1–10 in) in diameter, glaucous green, turning slightly yellowish at maturity. Peduncle 5–8 cm (2–3.2 in) long but hidden in the stem apex, the cone appearing nearly sessile. Median sporophylls 7–8 cm (2.8–3.2 in) long. Sporophyll face 4–5 cm (1.6–2 in) high, 5.5–6.5 cm (2.2–2.6 in) wide, protruding about 1.5 cm (0.6 in), glabrous, rough and warty, deeply fissured, the terminal facet slightly more than half the diameter of the face, the facets not well defined at maturity. Sarcotesta pale yellow when ripe. Sclerotesta 29–33 mm (1.1–1.3 in) long, 19–23 mm (0.8–0.9 in) in diameter, light brown, smooth except for 10–11 indistinct longitudinal grooves. MALE CONES usually one to three, narrowly ovoid to subcylindrical, 30–50 cm (12–20 in) long, 6–10 cm (2.4–3.9 in) in diameter, blue-green. Peduncle 8–9.5 cm (3.2–3.8 in) long. Median sporophylls 4–4.5 cm (1.6–1.8 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) high, 22–28 mm (0.9–1.1 in) wide, projecting about 12 mm (0.5 in) into a drooping lip. Sporangia in a single somewhat heart-shaped patch. HABITAT: Mountainous grassland with outcrops of dolomite at an elevation of about 1200 m (3900 ft). Rainfall averages 600–800 mm (24–32 in) annually, falling mainly in summer. Summers are hot, and occasional frost may occur in winter. DISTRIBUTION: South Africa, Northern province, Drakensberg, north of Penge and south of the Downs, possibly extinct in the wild.

Encephalartos dolomiticus is part of the *E. eugene-maraisii* complex and after its discovery in the early 1970s was considered a form of that species, called the Wolkberg or Downs form. By 1988 enough evidence had been collected to describe it as a distinct species. It differs from *E. eugene-maraisii* in its glaucous green cones and its twisted, somewhat untidy looking leaves.

Encephalartos dolomiticus is more common in private collections than it is in habitat. It was one of the rarest species of the genus with about 700 individuals once in the wild. Information received in 1990 indicates that all specimens of this species at both known localities have been removed. If no new colonies of *E. dolomiticus* are located, the cycad must be considered extinct in the wild. It is impossible to know how many of them have survived transplanting. It is now incumbent upon the owners of these plants to make every effort to propagate them. If this is successful, it may be possible to reestablish this species in its habitat.

Cultivation of *Encephalartos dolomiticus* is not difficult. Cultivated plants have been reported to produce a greater number of larger cones and larger crowns of leaves than those in the wild. Because of its extremely dry habitat, a well-drained soil mix must be used and overwatering avoided. Occasional light frost does not cause leaf damage or seem to harm the plants in other respects. The availability of *E. dolomiticus* will depend on the garden production of offsets and seeds, which are as yet rarely available. *Encephalartos dolomiticus* must be rated as extremely endangered, with plants apparently extinct in the wild.

Encephalartos dyerianus Lavranos & D. L. Goode 1988

PLATES 252, 253

Encephalartos graniticolus Vorster, Robbertse & S. van der Westhuizen 1988a

Encephalartos dyerianus is named in honor of Robert Allen Dyer (1900–1987), one of the foremost researchers of South African cycads. **Stems** arborescent, erect or decumbent with age and larger size, suckering from the base to form clumps, 3–6 m (10–20 ft) tall, 40–60 cm (16–24 in) in diameter. **Leaves** numerous, forming a dense crown, straight, rigid, glabrous with a silvery bloom, 1.4–1.7 m (4.6–5.6 ft) long, 20 cm (8 in) wide, keeled, somewhat twisted toward the apex. Petiole not more than 6 cm (2.4 in) long and the leaf appearing almost sessile. Leaflets lanceolate, inserted at right angles to the rachis but twisted forward 45°, sometimes slightly overlapping, opposing leaflets lightly V shaped in cross section, abruptly reduced in length at the apex, basal leaflets reduced to prickles and these extending almost to the stem, median leaflets 17–24 cm (6.7–9.4 in) long, 13–18 mm (0.5–0.7 in) wide, margin usually entire and flat in adult specimens. **Female cones** one to five, erect, cylindrical, 30–60 cm (12–24 in) long, 18–24 cm (7.1–9.4 in) in diameter, narrowing abruptly to a conical apex, glabrous, gray-green at maturity. Peduncle 6–12 cm (2.4–4.7 in) long but hidden in the cataphylls at the stem apex, the cone appearing sessile. Median sporophylls 4.5–5 cm (1.8–2 in) high, 7–8 cm (2.8–3.2 in) wide, with six lateral facets and one central facet, the facets smooth and distinct. Sarcotesta orange-brown when ripe. Sclerotesta irregularly ovoid, the ends somewhat squared, 30–37 mm (1.2–1.5 in) long, 23–28 mm (0.9–1.1 in) in diameter, light brown, with 17–24 prominent longitudinal grooves. Chalaza 10–17 mm (0.4–0.7 in) in diameter, not raised. **Male cones** five to eight, narrowly ovoid, 27–46 cm (11–18 in) long, 9–12 cm (3.5–4.7 in) in diameter. Peduncle 10–17 cm (4–6.7 in) long. Median sporophylls about 1.5 cm (0.6 in) high and 2 cm (0.8 in) wide, the terminal facet slightly raised but not drawn out into a beak or lip. Sporangia in a single uniform patch covering the underside of the sporophyll. **Habitat:** Among large granite boulders in full sun at an elevation of about 700 m (2300 ft). Rainfall averages 400–500 mm (16–20 in) annually, falling only in summer. Summer temperatures are hot, and winters are mild. **Distribution:** South Africa, northeastern Northern province, a few kilometers north of the town of Mica.

In the early 1970s when *Encephalartos dyerianus* was discovered it was considered a form of *E. eugene-maraisii* and for a number of years was known as the Mica form of that species. When sufficient data were available finally to describe the cycad as a distinct species, two groups of botanists published descriptions within a week of each other. The earliest has priority, thus the valid name is *E. dyerianus* instead of *E. graniticolus.*

Encephalartos dyerianus has one of the most restricted ranges of any cycad and is found only at a single locality in the Northern province, South Africa. The area in which it grows consists of plains interrupted by a chain of low granite hills, and *E. dyerianus* occurs on only one of these hills in a colony of approximately 600 plants. This cycad is quite robust and one wonders why it should only occur on one of a group of apparently identical granite hills. Seed production is good if somewhat sporadic, but regeneration in habitat is almost nil. When I visited the site in 1990 there were hundreds of seeds, produced in 1988, scattered under the female plants, but not one seedling could be found! The only immature plants in the colony were seedlings that had been planted some years previously by the Transvaal Division of Nature Conservation.

Encephalartos dyerianus, because of its restricted habitat and relative rarity, is not often seen in cultivation. The single male specimen I have grown for a number of years seems quite at home in the southern California climate in spite of winter rainfall. It has grown well but has coned only once. There has been no apparent damage caused by winter freezes. Generally speaking, it is handsome, undemanding, and easily grown. The requirements of good growth would seem to be well-drained soil, full sun, and frequent applications of fertilizer. There have been no problems with insect pests.

Habitat was acquired by the Transvaal Division of Nature Conservation in 1970, and in 1972 the Lillie Flora Reserve was proclaimed, specifically dedicated for the conservation of rare flora, in this case the single colony of what would become *Encephalartos dyerianus.* The hill was fenced and a permanent guard posted there soon after the presence of the cycads was known. Seed has been collected by this same organization, and in the past a considerable number of plants have been grown by the Provincial Nursery for distribution to private collectors and for planting at the site to increase the natural community. Even though *E. dyerianus* is protected it must be considered very endangered because of its limited distribution and relatively small numbers.

Encephalartos equatorialis P. J. H. Hurter & Glen 1995

PLATES 254–257

Encephalartos imbricans Vorster in Vorster & Heibloem 1995a (December)

The epithet for *Encephalartos equatorialis* refers to this cycad's habitat, near the equator. **Stems** arborescent, usually solitary but suckering profusely from the base to form large clumps, attaining a maximum length of 3.5–4.2 m (11–14 ft), 35–45 cm (14–18 in) in diameter. **Leaves** numerous, erect, rigid, linear oblanceolate, apex curved slightly backward and downward, forming a dense crown, green, 3.1–3.4 m (10–11 ft) long, 35–43 cm (14–17 in) wide, tapering abruptly to the rounded apex and gradually toward the base. Petiole almost lacking, to 13 mm (0.5 in) long with a bulbous base, at first tomentose but glabrous when mature. Rachis at first tomentose, becoming glabrous with age, ovate in cross section, bisulcate above with the leaflets attached within the grooves. Leaflets leathery, rigid, ascending, angled forward about 30°, opposing leaflets at an angle of about 90° to each other, producing a V-shaped cross section and overlapping mainly in a downward direction, the lower edge of the leaflet overlapping the upper edge of the leaflet below, but the leaf apex with leaflets overlapping in an upward direction, the upper edge of the leaflet overlapping the lower edge of the leaflet above, median leaflets 20–26 cm (8–10 in) long, 2–2.6 cm (0.8–1 in) wide, narrowly elliptical, gradually acuminate, pungent, apex somewhat directed toward the leaf apex, margins slightly thickened, with three to six teeth on each side. **Female cones** usually one to three, erect, ovoid, 36–40 cm (14–16 in) long, 18–20 cm (7.1–8 in) in diameter, dark green. Peduncle 3–4 cm (1.2–1.6 in) long. Median sporophylls about 6 cm (2.4 in) long. Sporophyll face rhombic, about 3 cm (1.2 in) high and 5.5 cm (2.2 in) wide, the facets somewhat wrinkled, the lateral facets distinct, median facets ill defined, terminal facet concave. Sarcotesta orange-red when ripe. Sclerotesta ovoid, 35–38 mm (1.4–1.5 in) long, 23–30 mm (0.9–1.2 in) in diameter, smooth. **Male cones** usually five to eight, 30–40 cm (12–16 in) long, 9–10 cm (3.5–4 in) in diameter, glaucous green, glabrous. Peduncle 20–30 cm (8–12 in) long. Median sporophylls slightly ascending, 2.5–3 cm (1–1.2 in) long. Sporophyll face subtriangular, 10–15 mm (0.4–0.6 in) high, 21–24 mm (0.8–0.9 in) wide. Sporangia in a single patch covering the entire underside of the sporophyll. **Habitat:** Exposed granite hilltop with a western exposure in full sun, associated with minimal vegetation. **Distribution:** Uganda, northern shore of Lake Victoria in the area of Thruston Bay.

The accelerated investigation of *Encephalartos* in central Africa since the 1970s has culminated in the descriptions of nine new species. Three of these, *E. equatorialis, E. macrostrobilus,* and *E. whitelockii,* were described from Uganda. Continuing exploration and research in central Africa will no doubt disclose additional distinct forms of *Encephalartos.*

It appears that *Encephalartos equatorialis* is a relict species on the verge of extinction. Only two colonies are known, comprising approximately 300 plants. Viable seed is no longer produced in these colonies, and a search for insect pollinators in fresh cones has not been successful. There are no juvenile plants in these colonies, which seem to rely on the production of basal offsets to increase numbers.

There are few plants of *Encephalartos equatorialis* in cultivation, but they do not seem to pose any horticultural problems. This species should have a subtropical to tropical climate for best results, but it would probably survive in warm temperate climates as well. The large size and spiny leaves of *E. equatorialis* could cause problems in small gardens, and this must be kept in mind when using it in the landscape. It is a beautiful cycad that would no doubt be very popular if a source of viable seed were ever found. Until that time, removal of offsets may be the sole source of propagation material.

Encephalartos equatorialis must be considered endangered. The complete lack of reproduction in habitat and the isolated nature of the colonies, consisting of only a few hundred individuals, do not bode well. Both colonies are completely surrounded by agriculture and human habitations. It has also been reported that a number of plants have been removed more recently.

Encephalartos eugene-maraisii I. C. Verdoorn 1945

PLATES 258–261

Encephalartos eugene-maraisii, named in honor of Eugene Nielen Marais (1872–1936), the naturalist responsible for bringing this cycad to the attention of botanists, and the uncle of Inez Clare Verdoorn, who described the species, is called *wildedadels* wild dates, in Afrikaans, referring to the seeds, which in size and color somewhat resemble dates. **Stems** arborescent, erect or in very large specimens leaning or decumbent, suckering freely from the base to produce clumps, 2 m (6.6 ft) tall, rarely as tall as 3 m (6.6–10 ft), 30–40 cm (12–16 in) in diameter, apex crown shaped and covered with narrowly acuminate gray-white tomentose bracts. **Leaves** numerous, spreading, with a light gray or silver bloom, 1–1.5 m (3.3–4.9 ft) long, 10 cm (4 in) wide, strongly keeled, spreading and held almost horizontal to the crown. Petiole smooth, 16–18 cm (6.3–7.1 in) long, 1–1.2 cm (0.4–0.5 in) in diameter, terminating at the broadened and densely tomentose base. Rachis more or less straight but the terminal third of the leaf curved slightly inward. Leaflets rigid, leathery, abruptly narrowed at the pungent apex, unequally acuminate with the lower margin longest, at an oblique angle to the rachis and overlapping in an upward direction, the lower surface of the leaflet facing the rachis, basal leaflets reduced and ending in a single prickle, median leaflets 15–20 cm (6–8 in) long, 13–15 mm (0.5–0.6 in) wide, margins entire or occasionally with one or two teeth on the lower margin. **Female cones** one to six, somewhat ovoid, 30–50 cm (12–20 in) long, 16–20 cm (6.3–8 in) in diameter, maroon or dark brown-red, with a cap of sterile sporophylls that are reduced in size. Peduncle 5–6 cm (2–2.4 in) long but usually not visible, the cone appearing sessile. Median sporophylls 25–32 mm (1–1.3 in) high, 45–65 mm (1.8–2.6 in) wide, slightly wrinkled and pimply. Sarcotesta light brown to amber or yellow when ripe. Sclerotesta 28–33 mm (1.1–1.3 in) long, 22–25 mm (0.9–1 in) in diameter, light brown, more or less smooth, sometimes with 8–10 very faint longitudinal grooves. Chalaza 1–1.5 cm (0.4–0.6 in) in diameter, composed of numerous shallow pits. **Male cones** one to eight, upright or leaning to the side, spindle shaped, 22–42 cm (8.7–17 in) long, 6–8 cm (2.4–3.2 in) in diameter, maroon or dark brownred. Peduncle 6–9 cm (2.4–3.5 in) long, 2–2.5 cm (0.8–1 in) in diameter, cylindrical in cross section, with several pronounced vertical grooves and tomentose cataphylls. Sporophylls about 3 cm (1.2 in) long. Sporophyll face 10–15 mm (0.4–0.6 in) high, 20–27 mm (0.8–1.1 in) wide, projected into a beak 7–10 mm (0.3–0.4 in) long, ending in a liplike projection 1 cm (0.4 in) wide, its lower edge very irregular. Sporangia in a single somewhat uniform patch with a sterile border on each side. **Habitat:** Among rocks or on steep rocky slopes in dry scrub, at elevations of 1400–1500 m (4600–4900 ft). Rainfall averages 625–750 mm (25–30 in) annually, falling mainly in summer. Winters are cold but generally frost-free. **Distribution:** South Africa, Northern province, restricted to the northwestern part of the Waterberg.

The cycad that was to become *Encephalartos eugene-maraisii* was first brought to the attention of the botanical community in 1925 by Eugene Marais. He dispatched a leaf and some seeds to Hermann Wilhelm Rudolf Marloth, who had published a treatment of the cycads in *The Flora of South Africa.* As no other cycads had been reported in the western Transvaal, now the Northern province, the accuracy of the report was considered doubtful. Then in the 1930s additional specimens were collected in the area of the Waterberg by two botanists, Illtyd Buller Pole-Evans and Ernest Edward Galpin. These specimens came to the attention of Inez Clare Verdoorn, a research worker at the Botanical Research Institute, Pretoria. It happened that Marais was her uncle. Verdoorn, with the aid of P. Toerien, an agricultural extension officer at Potgietersrust, rediscovered the cycad in 1944. She described it in 1945, honoring her uncle and the cycad's discoverer.

Encephalartos eugene-maraisii grows well, if not rapidly, in cultivation and is reasonably cold tolerant. The light silvery bloom, the unusual arrangement of the leaflets, and the almost horizontal aspect of the leaves, with their tips curved inward, make this a most remarkable cycad. Viable seed is not often available, so seedlings are generally in short supply. Seedlings grow slowly at first but more rapidly after the first 2–3 years. Adult plants do best in full sun, and seedlings in bright light such as under 50% shade cloth. Well-drained soil is a must, and periodic applications of fertilizer during the growing season will speed growth. The cones are very decorative, and viable seed is not difficult to produce if fresh pollen is applied when the female cone is receptive. I am not aware of any natural hybrids, but some years ago I successfully crossed *E. eugene-maraisii* with *E. concinnus.* The resulting plants were quite interesting, with the leaf morphology about midway between the two parents and the leaflet surface displaying a speckled coloration.

Encephalartos eugene-maraisii must be considered extremely endangered. The unique beauty of this cycad has made it one of the most sought after species of the genus. This popularity has resulted in the majority of these plants being illegally removed from their habitat. When I studied this cycad in 1958 it was not common but could be found in small scattered colonies. Most of those colonies are gone. Regeneration in habitat even at that time was not good and must now be almost completely lacking. Propagation will now have to depend on cultivated plants, this species' last foothold on survival.

Encephalartos ferox G. Bertoloni 1851

PLATES 262–265

Encephalartos kosiensis Hutchinson 1932

Encephalartos ferox, the epithet Latin for fierce, referring to the very spiny leaflets, is called holly-leaved cycad, *chi-*

hanga, chipissana, and *untopani* in Mozambique, and *isiqiki somkhovu* in South Africa. Stems subterranean or arborescent, usually solitary, rarely suckering from the base, densely tomentose, crown generally at ground level through the action of contractile roots but occasionally producing an aerial stem 1–2 m (3.3–6.6 ft) tall, 30–35 cm (12–14 in) in diameter. Leaves numerous, spreading, glossy dark green, 1–2 m (3.3–6.6 ft) long, 30–36 cm (12–14 in) wide, straight or slightly arching, flat, emergent leaves densely tomentose but glabrous with age. Petiole 9–24 cm (3.5–9.4 in) long, 15–18 mm (0.6–0.7) in diameter. Median leaflets 15–18 cm (6–7.1 in) long, 3.5–8 cm (1.4–3.2 in) wide, somewhat broader above the midpoint, margins with two to four small to large teeth, terminating in three to five pungent lobes at the apex, sometimes but not always twisted out of the leaflet plane. Female cones usually one to three but in old, very large plants as many as five, ovoid, 25–50 cm (10–20 in) long, 20–40 cm (8–16 in) in diameter, ranging from yellow (rarely) and orange to bright red. Peduncle very short, cone appearing sessile. Sporophyll face 15–18 mm (0.6–0.7 in) high, 38–42 mm (1.5–1.7 in) wide, somewhat wrinkled and ending in a pronounced beak, the facets distinct. Sarcotesta bright red when ripe. Sclerotesta ovoid, 44–50 mm (1.7–2 in) long, 15–20 mm (0.6–0.8 in) in diameter, more or less smooth. Male cones one to three, in larger plants sometimes as many as 10, subcylindrical, 40–50 cm (16–20 in) long, 7–10 cm (2.8–4 in) in diameter, yellow (rarely) to pink or scarlet. Peduncle 10–15 cm (4–6 in) long, 26–35 mm (1–1.4 in) in diameter, furrowed, with scattered cataphylls. Sporophyll face 9–12 mm (0.4–0.5 in) high, 20–22 mm (0.8–0.9 in) wide, the facets distinct. Sporangia in a single patch with a sterile notch at the front. Habitat: Coastal scrub on stabilized sand dunes, or when found farther inland in wooded scrub, generally in the shade of taller vegetation. Rainfall is 1000–1250 mm (39–49 in) annually, falling mainly in summer. The climate is typically hot and humid, and no frost occurs. Distribution: South Africa, from Zululand, northeastern KwaZulu-Natal province to near Sordwana Bay, which is about 650 km (400 miles) north of Maputo, Mozambique.

The person credited with the discovery of *Encephalartos ferox* was an Italian plant collector, Cavaliere Carlo Antonio Fornasini. From 1839 onward, Fornasini collected many plant specimens in the Inhambane district of Mozambique (then Portuguese East Africa) that were sent to Giuseppe Bertoloni in Bologna, Italy. One of Fornasini's specimens was a large cycad leaf, which Bertoloni described in 1851 as *E. ferox.*

In July 1920, two South African botanists, Robert Aitken and George Gale, visited Pondoland (now Maputaland) in what is now northern KwaZulu-Natal, south of Maputo, Mozambique. In the area of Kosi Bay they discovered a cycad they thought was undescribed. Several other collections were made in this same area until about 1930. Two botanists from the Royal Botanic Gardens, Kew, England, Arthur William Hill and John Hutchinson, visited Durban and noted several plants in local gardens. Hutchinson, not realizing that the cycad had already been named, described it as *Encephalartos kosiensis,* now a synonym of *E. ferox.*

As one would expect of a plant with such an extended range, *Encephalartos ferox* displays considerable variation. Generally, the stems are subterranean as a result of the action of their contractile roots, but in the northern limits of the cycad's range in Mozambique, stems as long as 2 m (6.6 ft) are not rare. Leaflets vary from flat with small marginal spines, ruffled with lobes twisted out of the leaflet plane, and finally, with rolled margins, giving an almost tubular effect (Plate 264). The plants with the rolled leaflets, sometimes called curly-leaved *ferox,* are from the district of Gaza, near Chongoene, Mozambique. I received a shipment of this form in 1961 plus some photographs of them in habitat. All the plants had the same rolled leaflets and were very regular in their leaf morphology. Plants in cultivation at the Fairchild Tropical Garden and Montgomery Botanical Center, Miami, Florida, have coned, and the cone color and sporophylls are different from common *E. ferox.* This population deserves to be studied more critically, with a view to its being described as a separate taxon.

Encephalartos ferox has been known in past years to be used as food in Mozambique, where the stems were split and the pith removed. As in other cycads, this pith is almost pure starch and when properly processed will produce a fine flour.

Encephalartos ferox is without doubt one of the most beautiful and interesting of the African cycads. It is fast growing, easy to grow, and readily available. These attributes make *E. ferox* one of the most familiar cycads in botanical gardens, conservatories, and private collections. Colorful cones are unusual in cycads, most of which tend toward shades of brown and green. *Encephalartos ferox* is a notable exception with cones usually bright red, red-orange, rarely yellow. They are the most colorful cycad cones known. Cultivation of *E. ferox* is quite simple. Provided with well-drained soil, sufficient fertilizer, and a bit of heat, it is one of the most rapidly growing cycads. In cultivation, *E. ferox* has been known to reach coning size in less than 10 years.

Most of the wild populations of *Encephalartos ferox* grow along the coastline of South Africa and Mozambique in pure sand. Usually, they are found under some sort of tree cover, affording them protection from the brutal heat that is common in their habitat. Loss of habitat, in Mozambique as a result of increased human habitation and in South Africa as a result of deforestation, has reduced this cycad's range, seeming to set a trend for the future. In more recent years, collection of plants for the nursery trade has also taken its toll. Because of its extensive range, much of it in uninhabited areas, it has remained in relatively large numbers. Yet the conservation status of *E. ferox* should probably be considered as threatened.

Encephalartos friderici-guilielmi Lehmann 1834

PLATES 266, 267

Encephalartos friderici-guilielmi, named in honor of Friedrich Wilhelm III (1770–1840), king of Prussia and a patron of botany, is called the Kaiser's cycad. Stems arborescent, solitary or suckering from the base to form large clumps, often leaning, to 4 m (13 ft) tall, 35–60 cm (14–24 in) in diameter, with an open, woolly brown crown. Leaves numerous, stiff, straight or slightly curved, spreading horizontally, usually at an angle of about 90° to the crown, often lower than the crown, especially when in cone, 1–1.5 m (3.3–4.9 ft) long, 18–20 cm (7.1–8 in) wide. Petiole round in cross section, glabrous, 17–30 cm (6.7–12 in) long. Leaflets somewhat silvery when young, yellowish with age, closely packed and overlapping in upper half of the leaf, reduced in size toward the apex and base, lower leaflets not reduced to spines, median leaflets 10–17 cm (4–6.7 in) long, 7–8 mm (0.3 in) wide, with seven to nine prominent veins on the lower surface, margin without teeth but the apex armed with a sharp spine. Female cones one to six, barrel shaped, 25–30 cm (10–12 in) long, 15–20 cm (6–8 in) in diameter, covered with yellowish gray or brownish wool, yellow beneath the wool, with a rounded apex. Peduncle short, cone appearing sessile. Sporophylls 4.5–5 cm (1.8–2 in) long. Sporophyll face flattened, 2.5 cm (1 in) high, 4.5–5 cm (1.8–2 in) wide, beneath the wool more or less smooth except for a lateral ridge. Sarcotesta pale yellow to pale orange-yellow when ripe. Sclerotesta long ovoid to subglobose, somewhat flattened, 24–33 mm (1–1.3 in) long, 16–20 mm (0.6–0.8 in) in diameter, medium brown, with about 10–13 shallow but distinct longitudinal grooves. Chalaza 7–13 mm (0.3–0.5 in) long, 5–9 mm (0.2–0.4 in) wide, with indistinct pits. Male cones 3–12, cylindrical, 20–40 cm (8–16 in) long, 6–10 cm (2.4–3.9 in) in diameter, narrowed toward the apex, covered with brownish wool. Peduncle short, cone appearing sessile. Sporophylls 25–28 mm (1–1.1 in) long. Sporophyll face 7 mm (0.3 in) high, 17–20 mm (0.7–0.8 in) wide, with a beak projecting about 5 mm (0.2 in). Sporangia in a single patch with a large sterile notch at both front and back. Habitat: Mountainsides and rocky slopes with sparse dry vegetation. Rainfall averages 375–500 mm (15–20 in) annually, falling in summer. Summers are hot, and winters cold with considerable frost and snow. Distribution: South Africa, Eastern Cape province, Cathcart and Queenstown districts, extending eastward to the area of Kokstad.

Encephalartos friderici-guilielmi was long confused with *E. cycadifolius* and referred to under that name. This was the result of the scant information used in botanical descriptions in the early 1800s. The location for both species was given as "Eastern Cape." After its description, *E. cycadifolius* was not identified again in its habitat for many years, and it was generally accepted that *E. friderici-guilielmi* was the same plant. Since both species have a similarity in leaflets and other features, it is easy to see how the confusion began. When the original *E. cycadifolius* was rediscovered, it was described as a new species, *E. eximius.* Later, when those plants were found to agree with the original description of *E. cycadifolius, E. eximius* became a synonym and the name *E. friderici-guilielmi* was reinstated for the populations at Cathcart and Queenstown. It is generally accepted that the closest relatives of *E. friderici-guilielmi* are *E. cycadifolius* and *E. ghellinckii.* Present-day colonies of *E. friderici-guilielmi* do not overlap the distribution of any other species of the genus, and no natural or artificial hybrids are known to exist.

Encephalartos friderici-guilielmi, though plentiful in nature, is not well represented in botanical gardens or private collections. This is surprising, as it is an easy plant to grow and adapts well to various climatic conditions. Undemanding in most respects, it requires only a sunny position and well-drained soil. Growth is relatively rapid with proper cultivation, and the plants are robust. The species is both drought and frost tolerant and adapts well to winter-rainfall areas. *Encephalartos friderici-guilielmi* is a majestic plant and well-grown examples are an asset to any garden, either public or private. Mature plants cone freely, and this species is unusual in the large numbers of both male and female cones that it produces. Male plants may produce as many as 12 cones, females as many as 6. It is possible that a single female plant with 6 cones could produce approximately 1800 seeds! This would explain the large numbers of individuals to be found in each colony. Climatic conditions are harsh in this plant's habitat, allowing relatively few seedlings to survive. Even so, all colonies show good regeneration.

There was a time when *Encephalartos friderici-guilielmi* was very abundant and could be seen along the roadsides near Queenstown and Cathcart. At that time, one could also see large numbers of this species in the mountains surrounding Queenstown. Sadly, none of these plants is left. All have been removed by plant dealers and collectors or destroyed by road construction. Even with the loss of hundreds, if not thousands, of plants, *E. friderici-guilielmi* is still common in the more remote sections of its range. The cycad prefers rocky ground and steep hillsides, so it is not threatened by farming development. Usually, the only use of this land is for grazing, which does not generally affect the cycad populations adversely. This cycad should be considered threatened, but the plants are not in immediate danger.

Encephalartos ghellinckii Lemaire 1867a

PLATES 268–271

Encephalartos ghellinckii is named in honor of Édouard de Ghellinck de Walle, noted amateur botanist from Ghent, Belgium, who maintained an extensive private plant collection. **Stems** usually unbranched but often suckering from the base, to 3 m (10 ft) tall, 30–40 cm (12–16 in) in diameter, often leaning in old age, with a somewhat open and woolly brown crown. **Leaves** numerous, dark green, 0.7–1 m (2.3–3.3 ft) long, 12.5–15 cm (5–6 in) wide, curved inward, the whole leaf sometimes spirally twisted, juvenile foliage densely brown woolly, the wool weathering off with age. Petiole 20–25 cm (8–10 in) long. Leaflets in about 130 pairs, dense, spreading, directed downward from the rachis, forming an inverted V in cross section, median leaflets 8–14 cm (3.2–5.5 in) long, 2–4 mm wide, apex acute, margin entire and strongly revolute. **Female cones** two to five, ovoid, 22–25 cm (8.7–10 in) long, 12–15 cm (4.7–6 in) in diameter, densely brown woolly, rounded at apex. Peduncle short and stout, the cone appearing sessile. Sporophyll face 2.5–3 cm (1–1.2 in) high, 5–5.5 cm (2–2.2 in) wide, only slightly projecting, the facets indistinct. Sarcotesta golden yellow when ripe. Sclerotesta ovoid to subglobose, 25–34 mm (1–1.3 in) long, 18–23 mm (0.7–0.9 in) in diameter, brown, with 12–15 indistinct longitudinal grooves. Chalaza not prominent, 11–16 mm (0.4–0.6 in) long, 9–13 mm (0.4–0.5 in) wide, with shallow pits. **Male cones** two to seven, cylindrical, sometimes slightly curved, 20–25 cm (8–10 in) long, 6–7 cm (2.4–2.8 in) in diameter, narrowing at either end, covered with a thick pale brown mat of hairs. Peduncle 3–5 cm (1.2–2 in) long but hidden among the cataphylls, the cone appearing sessile. Sporophylls rhomboid, 10–13 mm (0.4–0.5 in) high, 15–25 mm (0.6–1 in) wide, densely tomentose, the facets indistinct. Sporangia in a single uniform patch on the underside of the sporophyll. **Habitat:** Rocky areas of grassland, usually on south- and east-facing slopes above 700 m (2300 ft) to elevations as high as 2400 m (8000 ft). Rainfall averages 1000–1250 mm (40–50 in) annually. Winters are very cold, with frequent frosts and snow. **Distribution:** South Africa, extending from Tabankulu to Flagstaff districts, Eastern Cape province, along the southern foothills of the Drakensberg northward through the mountain range to Mont-aux-Sources, KwaZulu-Natal province.

Antoine Charles Lemaire described *Encephalartos ghellinckii* in *L'Illustration Horticole* in 1867. It is believed that he obtained his specimens from Ambroise Verschaffelt, a plant dealer in Belgium.

There are two distinct ecotypes or forms of *Encephalartos ghellinckii* in South Africa. The one originally described, from the Drakensberg (Plates 268, 269), is a robust plant, producing thick, upright stems to 3 m (10 ft) tall. These plants have dark green leaves that when emergent are densely covered with brown hairlike tomentum. The second form, from lower elevations in the Eastern Cape province (Plates 270, 271), including the Transkei, has shorter, less robust stems that are generally decumbent when more than 1 m (3.3 ft) long. These plants sucker freely and have smaller leaves that are finely white to tan tomentose when emergent.

Encephalartos ghellinckii in its habitat is subjected to wide ranges of temperature, from freezing cold and snow in winter to extreme heat and drying winds in summer. In spite of these difficult conditions, the only time the plant does not make a good appearance is after the periodic grass fires. The disreputable appearance of the plants is short-lived because new leaves are produced shortly after the old crown has been burned off. These fires appear to stimulate cone production while clearing away grass and brush from around the cycads. The Drakensberg is probably one of the most beautiful mountain areas in the world. To spend a day in the midst of these cycads, with the majestic peaks of the Drakensberg as a backdrop, is an unforgettable experience.

Encephalartos ghellinckii is not often seen in either public or private gardens, mainly the result of the difficulty encountered in transplanting. Even when relocation has been successfully accomplished, the plants do not seem to take kindly to their new homes. Cultivated plants seldom appear perfectly healthy, and production of cones is rare. Plants grown from seedlings seem to adjust much better to artificial conditions, but seeds and seedlings are not often available. Whatever the problems, this is a cycad well worth the trouble to cultivate. It should be noted that the form from the Eastern Cape is much easier to reestablish and grow.

The conservation status of *Encephalartos ghellinckii* seems relatively secure. A large portion of its habitat occurs within protected parks and forests. That and its generally remote habitat tend to protect the plants from poaching. *Encephalartos ghellinckii* can be considered as not threatened.

Encephalartos gratus Prain 1916

PLATES 272, 273

The epithet for *Encephalartos gratus* is Latin for pleasing or welcome, referring to this cycad's appearance. **Stems** solitary, globose or to 1.2 m (3.9 ft) tall, 60 cm (24 in) in diameter. Cataphylls triangular, gradually acuminate, 8–12 cm (3.2–4.7 in) long, 3–4 cm (1.2–1.6 in) wide at the base, usually with a covering of woolly tomentum on the lower side. **Leaves** numerous, arching, oblanceolate or linear oblong, 0.9–1.8 m (3–5.9 ft) long, 34–44 cm (13–17 in) wide, flat, apex rounded, base abruptly tapered. Petiole 10–12 cm (4–4.7 in) long, base swollen and covered with a close, brownish buff tomentum. Rachis subterete, smooth or with decurrent shallow grooves from the leaflet bases. Leaflets in 30–70 pairs, not overlapping, dull green, flexible, straight or arching forward, basal leaflets gradually reduced to spines, median leaflets lanceolate, 18–26 cm (7.1–10 in) long, 23–35 mm (0.9–1.4 in) wide, margins with two to seven spines on the upper margin, often in the basal curve, the lower margin with none to six spiny teeth. **Female cones** 1–10, cylindrical to subconical, 55–68 cm (22–27 in) long, 15–20 cm (6–8 in) in diameter, dark brown. Peduncle 11.2–13.7 cm (4.4–5.4 in) long, 5–7.5 cm (2–3 in) in diameter. Median sporophylls about 30 mm (1.2 in) high and 56 mm (2.2 in) wide. Sarcotesta dull vermilion when ripe. Sclerotesta ovoid, 30–37 mm (1.2–1.5 in) long, 19–21 mm (0.7–0.8 in) in diameter, tan, the surface more or less smooth, with 11–14 very indistinct longitudinal grooves. Chalaza 10–15 mm (0.4–0.6 in) long, 8–15 mm (0.3–0.6 in) wide. **Male cones** one to five (or more?), ovoid to spindle shaped, 30–40 cm (12–16 in) long, 7.5–10 cm (3–4 in) in diameter, densely red-brown tomentose. Peduncle 15–17.5 cm (6–7 in) long, dull yellowish green dotted with deep red, tomentose. Median sporophylls about 19 mm (0.8 in) high and wide. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Rocky ravines and along rocky riverbanks, frequently in rock crevices with no apparent soil, also in savanna where annual grass fires usually defoliate the plants, at elevations of 675–925 m (2200–3000 ft). Rainfall averages 1000–1750 mm (39–69 in) annually, falling mainly in summer. High temperatures average 35–38°C (95–100°F). **Distribution:** Malawi, Mount Mulanje, and more recently, sightings reported in Mozambique near Mavita, and in the Serra Namuli northeast of Gurué (Vila Junqueiro).

The first reports of a cycad from south of Lake Nyasa (now Lake Malawi) were received in 1899 from John Mahon, Government Forester stationed at Zomba, British Protectorate of Nyasaland (now Malawi). Herbarium specimens were sent to the Royal Botanic Gardens, Kew, that had been collected on the southwestern slopes of Mount Mulanje at an elevation of about 850 m (2800 ft). John McClounie and E. W. Davey sent additional collections in 1903, 1914, and 1916. These collections and data were used by David Prain when he described *E. gratus* in 1916.

Encephalartos gratus seems to be most closely related to *E. hildebrandtii* but may have ties to *E. manikensis* as well. Some intermediate forms have been reported between *E. gratus* and *E. manikensis,* but additional fieldwork is needed to clarify these relationships.

Encephalartos gratus commonly grows in rocky areas along riverbanks and survives occasional submersion during heavy floods. It grows in full sun on rocky areas and can also be found on deep, rich soils under forest cover. Some plants are found in savanna, where the annual grass fires routinely defoliate them.

Denis Heenan (1977) reported that all female cones of *Encephalartos gratus* seen in habitat had produced apical leaves. There were two colonies involved, that in the Serra Namuli, Mozambique, and at the type locality of Mount Mulanje, Malawi. The Malawi specimens were said to produce about six apical leaves 10–20 cm (4–8 in) long whereas the Serra Namuli plants produced apical leaves just over 1 m (3.3 ft) long.

Encephalartos gratus, though of restricted range, is relatively common in collections because of the high rate of viability of the seeds and the large numbers of seeds produced on a single plant. It is easy to cultivate, and growth is very rapid. Sizable plants can be produced from seed in 10 years. Seed is easily set on cultivated plants where weather conditions permit them to be grown in the ground. It has been reported that female plants may sometimes remain leafless 12–18 months after ripening seeds. This is not surprising as *E. gratus* has been found with as many as 10 female cones on one plant. The energy needed to mature that number of cones must surely tax the plant's reserves.

The conservation status of *Encephalartos gratus* is secure. The extensive propagation of this cycad, and its rapid rate of growth, seem to have produced sufficient numbers to curtail poaching. It can be considered as not threatened.

Encephalartos heenanii R. A. Dyer 1972

PLATES 274–276

Encephalartos heenanii is named in honor of Denis Heenan, a cycad collector in Piggs Peak, Swaziland, who first brought this species to the attention of Robert Allen Dyer, who subsequently described it. **Stems** arborescent, often suckering from the base, erect or leaning, to about 2.3 m (7.5 ft) tall, 25–35 cm (10–14 in) in diameter, crown densely woolly. Cataphylls linear lanceolate, densely covered with long brown hairs, apex recurving and becoming dry and brittle. **Leaves** numerous, erect, oblong lanceolate, 1–1.3 m (3.3–4.3 ft) long, 15–20 cm (6–8 in) wide, inwardly curving to form a bowl-shaped crown, emergent leaves covered with long, brownish, woolly hairs, gradually glabrescent with age except for the base. Petiole to 20 cm (8 in) long, round in cross section. Rachis somewhat twisted. Leaflets spaced toward the leaf base, denser above and sometimes slightly overlapping, upper leaflets slightly curved toward the leaf apex, basal leaflets not reduced to prickles but the bottom one or two often lobed and somewhat pricklelike, median leaflets widely spreading or abruptly curved backward and downward from the rachis, 12–15 cm (4.7–6 in) long, 1.5–2 cm (0.6–0.8 in) wide, rigid, the lower leaflet surface with prominently raised veins, upper leaflet surface often with small wartlike protuberances, margin entire in adults or rarely with one or two prickles, juvenile forms almost always with a few marginal prickles. **Female cones** usually solitary, rarely as many as three, broadly ovoid, 20–35 cm (8–14 in) long, 17–20 cm (6.7–8 in) in diameter, densely shaggy brown woolly or rarely glabrescent, yellowish under the wool. Peduncle 5–6 cm (2–2.4 in) long, 4 cm (1.6 in) in diameter, densely tomentose. Median sporophylls 6–6.5 cm (2.4–2.6 in) long. Sporophyll face 2.5–3 cm (1–1.2 in) high, 5–5.5 cm (2–2.2 in) wide, projecting about 2.5 cm (1 in), shaggy woolly, the facets indistinct, rough and warty. Sarcotesta orange-yellow when ripe. Sclerotesta long ovoid, 30–40 mm (1.2–1.6 in) long, 18–22 mm (0.7–0.9 in) in diameter, somewhat three-angled, smooth except for 12–17 indistinct longitudinal ridges. **Male cones** solitary or in groups of two to four, broadly subcylindrical, 27–30 cm (11–12 in) long, 15–17 cm (6–6.7 in) in diameter, broadest slightly below center and narrowed slightly toward apex, densely shaggy brown woolly with hair about 1 cm (0.4 in) long. Peduncle 8–9 cm (3.2–3.5 in) long, 2.5–3.5 cm (1–1.4 in) in diameter, velvety tomentose. Sporophylls 6.5–7 cm (2.6–2.8 in) long, at right angles to the cone axis. Sporophyll face 2.5 cm (1 in) high, 5.5–6 cm (2.2–2.4 in) wide, projecting 13–15 mm (0.5–0.6 in), facets not distinct, the terminal facet flat, entire surface rough and warty. Sporangia in a single patch not extending to the edges of the sporophyll. **Habitat:** Steep rocky mountainsides with sparse grass and shrub growth at an elevation of about 1800 m (5900 ft). Rainfall averages about 1250 mm (49 in) annually, falling mainly in summer. **Distribution:** Swaziland, Piggs Peak district, Komatipoort. South Africa, Mpumalanga province, near Barberton.

The first report of the existence of *Encephalartos heenanii* was made in August 1969 by Denis Heenan of Piggs Peak, Swaziland, to Robert Allen Dyer of the Botanical Research Institute, Pretoria, South Africa. Heenan felt that the plant was distinct from *E. paucidentatus,* which occurred in the same general area. Upon examination of the leaf specimens, Dyer agreed that it appeared they were dealing with an undescribed species but that samples of female and male cones were necessary to complete the description. There were no cones produced in the known colonies until 1971, at which time Heenan collected the needed specimens. Dyer then completed the description and it was published in 1972.

Encephalartos heenanii is one of the most distinctive species of the genus. The very woolly leaves are curved inward, forming a bowl-shaped crown similar in shape to that of *E. ghellinckii.* The cones are equally woolly and are distinctive among other species of the genus (except *E. aemulans*) in that the female and male cones cannot easily be distinguished. The male cone, unlike that of most other species, is egg shaped like the female and does not exhibit the normal elongation when dehiscing pollen. Cones removed from the plant can be determined as to sex by the much lighter weight of the male.

The species most closely related to *Encephalartos hee-*

nanii is *E. paucidentatus. Encephalartos heenanii* grows in close proximity to both *E. laevifolius* and *E. paucidentatus.* Natural hybrids have been reported between *E. heenanii* and *E. paucidentatus.* No hybrids with *E. laevifolius* have been seen, and it is possible that a different pollinator may be involved in that species.

Encephalartos heenanii is notoriously difficult to grow. Mature plants seldom survive transplanting from their habitat, and if they do, it can take several years for them to reestablish. Even after successful reestablishment, *E. heenanii* will often display a deciduous growth habit and produce new leaves only after the death of the old crown. Smaller plants are less likely to be lost during transplanting and tend to become more robust than larger specimens. Cultivated plants seldom cone, and I am not aware of any viable seed produced from garden plants. The growth of seedlings is slow but does not seem to be coupled with any cultivation problems. Seeds and seedlings of *E. heenanii* are rare because of the erratic coning of plants in the wild. Despite all its problems in cultivation, *E. heenanii* remains one of the most sought after species of the genus.

The conservation status of *Encephalartos heenanii* is precarious. Apparently this species was never abundant, and illegal collecting, even before its description botanically, reduced its numbers to near extinction. It is protected in the Somgimvelo Nature Reserve, South Africa, and the Malolotja Nature Reserve, Swaziland. Additional plants are also protected by royal decree in the vicinity of the Kings Forest in Swaziland. A survey taken in 1985 found that fewer than 500 plants remained in the wild and that the numbers were dwindling even as the survey was in progress. The main factors affecting the conservation of *E. heenanii* are its very restricted distribution, intensive pressure from collectors, inability to reproduce in habitat, and encroachment on its range by reforestation activities. An *ex situ* conservation project has been started in the Lowveld National Botanical Garden, Nelspruit, South Africa, in an attempt to produce viable seed artificially. This project will take several years before its success can be evaluated. *Encephalartos heenanii* must be considered extremely endangered, on the brink of extinction.

Encephalartos hildebrandtii A. Braun & C. D. Bouché 1874

PLATES 277, 278

Encephalartos hildebrandtii var. *dentatus* Melville 1957

Encephalartos hildebrandtii, named in honor of Johann Maria Hildebrandt (1847–1881), botanist and explorer of East Africa, is called East African sago palm, *mtsapu* by the Rabai tribe, and *mkarabdka* by the Useguha tribe. **Stems** arborescent, erect, rarely branched, to 6 m (20 ft) tall, 30 cm (12 in) in diameter. Cataphylls linear to narrowly triangular, 10–15 cm (4–6 in) long, 4–35 mm (to 1.4 in) wide, densely yellowish tomentose outside, glabrous chestnut brown inside except for the tomentose tip. **Leaves** numerous, linear oblanceolate, stiff and straight, 2–3 m (6.5–10 ft) long, 30–65 cm (12–26 in) wide, tapering slightly toward the rounded apex and gradually toward the base, the swollen petiole base yellowish gray tomentose, with exposed parts glabrous at maturity. Rachis rounded above and shallowly grooved between the leaflets. Petiole 1–7 cm (0.4–2.8 in) long. Lower leaflets gradually reduced to simple spines extending almost to the swollen petiole base, median leaflets linear lanceolate, 15–35 cm (6–14 in) long, 13–45 mm (0.5–1.8 in) wide, leathery, glossy dark green above, paler below, with 26–40 parallel veins, apex acuminate, pungent or with two or three spiny teeth, margins each with one to nine spreading teeth, often crowded near the base of the leaflet, the lower margin nearly straight, the upper one arching. **Female cones** usually one to four, cylindrical, 28–60 cm (11–24 in) long, 15–25 cm (6–10 in) in diameter, dull yellow, apex rounded or abruptly tapering, base rounded. Peduncle 4–6 cm (1.6–2.4 in) long, 4–6 cm (1.6–2.4 in) in diameter. Median sporophylls deflexed, rhomboid, 20–33 mm (0.8–1.3 in) high, 35–50 mm (1.4–2 in) wide. Sarcotesta bright yellow to orange when ripe. Sclerotesta ovoid, 28–32 mm (1.1–1.3 in) long, 18–20 mm (0.7–0.8 in) in diameter, tan, smooth except for 12–14 very indistinct longitudinal grooves. Chalaza 9–12 mm (0.4–0.5) long, 8–11 mm (0.3–0.4 in) wide. **Male cones** one to seven, cylindrical to subconical or spindle shaped, 20–50 cm (8–20 in) long, 5–9 cm (2–3.5 in) in diameter, greenish to dull red (?). Peduncle 5–25 cm (2–9.8 in) long, 1.5–3 cm (0.6–1.2 in) in diameter, with scattered cataphylls. Median sporophylls deflexed, compressed rhomboid to subtriangular, 9–17 mm (0.4–0.7 in) high, 19–28 mm (0.8–1.1 in) wide, glabrous. Sporangia covering the lower side of the sporophyll in a regularly shaped patch except for a prominent notch at the outside edge. **Habitat:** Coastal evergreen bushland and lowland forest, in red loams and sandy soils among grass and coral rocks, from sea level to 600 m (2000 ft). **Distribution:** Kenya, Kilifi and Lamu districts. Tanzania, Lushoto and Tanga districts, and the island of Zanzibar.

The original discoverer of *Encephalartos hildebrandtii* was John Kirk, British consul general of Zanzibar, 1866–1886.

Kirk was a naturalist by hobby and kept up a constant correspondence with several of the botanists at the Royal Botanic Gardens, Kew. In a letter dated March 20, 1868, he announced that he had discovered a new species of *Encephalartos* on the coast near Dar es Salaam. Over the next 2 years, Kirk sent several shipments of live material to Kew, most of which did not survive the arduous trip. Long before the plants at Kew were large enough to be described, the German traveler and collector Johann Maria Hildebrandt rediscovered the species. Hildebrandt sent specimens to Berlin that were at once used by Alexander Carl Heinrich Braun and the curator of the Berlin Botanical Gardens, Carl David Bouché, to describe the new species, which they named after Hildebrandt in 1874.

The taxonomy of *Encephalartos hildebrandtii* originally brought together a number of scattered colonies of somewhat questionable relationship. Plants from the eastern Democratic Republic of the Congo (Zaire) and western Uganda at the Mapanga River Falls were accepted by David Prain (1917), William J. Eggeling (1940), and Walter Robyns (1948) as *E. laurentianus* (since then described as *E. ituriensis* and *E. whitelockii*). Ronald Melville (1957), with reservations, included these same plants under his broad concept of *E. hildebrandtii.* He remarked that these populations seemed to some extent intermediate between *E. laurentianus* of the Congo Basin and the typical *E. hildebrandtii* of the coastal areas of Kenya and Tanzania. He also stated that his opinion was based on "scanty and incomplete specimens of the two western forms" and felt it possible that when adequate material was available, their status might have to be reconsidered. The distinction between Melville's two varieties of *E. hildebrandtii, hildebrandtii* and *dentatus,* was based solely on cone characteristics, making identification impossible in sterile collections of mature plants. One would expect that the two varieties would exhibit other morphological differences, but Melville noted none. Johan Hurter (pers. comm.) of South Africa has done a great deal of field and taxonomic work in central Africa and in his opinion *E. hildebrandtii* var. *dentatus* is not worth recognizing, being based on minor cone variations. I agree.

Encephalartos hildebrandtii was used as a famine food in the past. In more recent times, both the central pith of the stem and the endosperm of the seeds have been used to prepare a form of starchy bread eaten by the indigenous tribes.

Encephalartos hildebrandtii is well represented in botanical gardens and private collections worldwide. Where the more tropical cycads can be grown, *E. hildebrandtii* is bound to be evident. Even though this cycad grows at or near sea level, and almost on the equator, it exhibits an unusual amount of cold tolerance by surviving in temperate areas as well. In the warmer portions of southern California it grows with apparent ease, only suffering defoliation or leaf burn during extreme winters. Well-drained soil, sufficient fertilizer, and a warm climate are all this cycad requires. A fast-growing plant, it will reach coning size in 8–10 years.

Encephalartos hildebrandtii may be considered threatened, with habitat destruction causing major inroads in its area of occurrence. In more recent years, a considerable quantity of viable seed has been artificially produced on cultivated plants. This seed normally has a high percentage of viability, and the numbers of *E. hildebrandtii* in cultivation has increased as a result of this seed production. If this trend continues, *E. hildebrandtii* could become common in cultivation.

Encephalartos hirsutus P. J. H. Hurter & Glen 1996

PLATES 279–281

The epithet for *Encephalartos hirsutus* is Latin for hairy, referring to the densely tomentose emergent leaves. **Stems** erect at first then decumbent when larger, to 3.5 m (11.5 ft) long, rarely as long as 4.2 m (14 ft), 35–40 cm (14–16 in) in diameter, crown densely golden brown tomentose, turning grayish with age, leaf bases persistent. **Leaves** numerous, rigid, strongly glaucous when young, 1.1–1.4 m (3.6–4.6 ft) long, 13–15 cm (5.1–6 in) wide, strongly keeled, apex curved slightly backward and downward, emergent leaves densely tomentose, the tomentum persisting for several months. Petiole to 13 cm (5.1 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, persistently tomentose, bulbous basally. Leaflets narrowly elliptical and falcate, glaucous, decurrent, angled forward about 50°, opposing leaflets at an angle of about 40° to each other, producing a V-shaped cross section and overlapping in an upward direction, the lower surface with prominent raised veins, basal leaflets gradually reduced but not to spines, median leaflets 13–17 cm (5.1–6.7 in) long, 2–2.4 cm (0.8–0.9 in) wide, apex ending in a sharp spine, margins entire except in immature leaves, which have scattered small teeth above and below. **Female cones** as many as three per crown, erect, ovoid, about 40 cm (16 in) long and 35 cm (14 in) in diameter, glaucous, glabrous. Peduncle to 6 cm (2.4 in) long but hidden among the cataphylls, the cone appearing sessile. Median sporophylls about 44 mm (1.7 in) long. Sporophyll face rhombic, about 2.5 cm (1 in) high and 5 cm (2 in) wide, the facets distinct, smooth, glabrous, with four lateral facets, two small medial facets, and a terminal facet. Sarcotesta orange-red when ripe. Sclerotesta long ovoid, 30–35 mm (1.2–1.4 in) long, 15–18 mm (0.6–0.7 in) in diameter, smooth. **Male cones** as many as five per crown, narrowly ovoid, erect, about 50 cm (20 in) long and 9 cm (3.6 in) in diameter, glaucous, glabrous. Peduncle about 12 cm (4.7 in) long. Sporophylls about 3 cm (1.2 in) long. Sporophyll face rhombic, about 7 mm (0.3 in) high and 29 mm (1.1 in) wide, the terminal facet flat or slightly concave. Sporangia in a single regularly shaped patch. **Habitat:** Exposed southeast-facing quartzite cliffs in moist semideciduous scrub, at elevations of 800–1000 m (2600–3300 ft). Rainfall averages 350–650 mm (14–26 in) annually, falling in summer. **Distribution:** South Africa, northern portions of the Northern province.

Encephalartos hirsutus is an extremely rare species that is restricted to three very small colonies from widely separated areas in the Northern province, South Africa. The distinctive morphology of the leaves and cones of this species makes it easily recognizable when it is grouped with other species of the genus. The numerous long, glaucous, arching, and strongly keeled leaves combine to make it one of the most beautiful species of *Encephalartos.* Distinctive also are the decurrent leaflet bases, and because of this feature the original name proposed for the species was *E. "decurrens."*

The closest relatives of *Encephalartos hirsutus* are the plants of the *E. eugene-maraisii* complex and *E. brevifoliolatus,* which are found in similar habitats. *Encephalartos hirsutus* can be easily separated from its near relatives by its smooth, glaucous sporophylls, heavily tomentose emergent leaves on which the tomentum persists for many months, the prominently raised veins on the underside of the leaflets, and the decurrent bases of the leaflets.

Because of its rarity, there are very few specimens of *Encephalartos hirsutus* in cultivation. What information I have been able to obtain would indicate that this species is a strong grower and has few, if any, problems in cultivation. Even very small offsets are said to strike roots quickly and reestablish. Because of its ease in cultivation, I have no doubt that artificial seed propagation will be possible.

Encephalartos hirsutus must be considered extremely endangered. Only three small populations are known, making the plants vulnerable to poaching. From the information available, viable seed is not being produced in habitat and seedling regeneration is nonexistent.

Encephalartos horridus (Jacquin) Lehmann 1834

PAGE 2–3, PLATES 11, 282, 283

Zamia horrida Jacquin 1801

The epithet for *Encephalartos horridus* is Latin for prickly or bristly, well chosen for this cycad. **Stems** generally subterranean, unbranched but producing many offsets from the base to create large clusters of stems, in rare cases to 1.5 m (4.9 ft) tall, 20–30 cm (8–12 in) in diameter, crown always sparsely woolly. **Leaves** numerous, erect, rigid, 0.5–1 m (1.6–3.3 ft) long, 10–15 cm (4–6 in) wide, curved sharply backward and downward toward the apex, juvenile leaves strikingly silver-blue, the color produced by a waxy coating that weathers away with age, the leaves becoming dull green. Petiole 12–15 cm (4.7–6 in) long, 1.2 cm (0.5 in) in diameter, with an expanded, light brown base. Lower leaflets reduced in size toward the base with the lowest ones consisting of one prickle, median leaflets 10–13 cm (4–5.1 in) long, 2.5–3 cm (1–1.2 in) wide, each leaflet with two or three prominent lobes to 4 cm (1.6 in) in length on the lower margin, the lobes twisted out of the leaflet plane and overlapping and interlocking with the adjoining leaflets, giving a very dense or crowded look, margins strongly revolute, the tips of leaflets and lobes armed with a stiff sharp spine. Mutant forms exist (Plate 11). **Female cones** solitary, ovoid, 20–40 cm (8–16 in) long, 15–20 cm (6–8 in) in diameter, ground color blue-green with a covering of blackish or brownish red tomentum. Peduncle about 8 cm (3.2 in) long and 3 cm (1.2 in) in diameter, hidden among the cataphylls, the cone appearing sessile. Median sporophylls 5–6 cm (2–2.4 in) long. Sporophyll face 3–3.5 cm (1.2–1.4 in) high, 4–4.5 cm (1.6–1.8 in) wide, projecting 17–20 mm (0.7–0.8 in), with a rough pimpled surface, the ridges between the facets distinct and smooth to corrugated. Sarcotesta pale red to carmine when ripe. Sclerotesta ovoid, 25–28 mm (1–1.1 in) long, 15–18 mm (0.6–0.7 in) in diameter, sometimes slightly triangular in cross section, smooth, light brown, often with lighter colored longitudinal lines. **Male cones** generally solitary, rarely two, subcylindrical, 20–40 cm (8–16 in) long, 6–12 cm (2.4–4.7 in) in diameter, narrowing from the center toward both ends, base color bluish green with a covering of black to reddish brown tomentum. Peduncle 40–45 mm (1.6–1.8 in) long, 21–26 mm (0.8–1 in) in diameter, dull green, with a heavy covering of black to red-brown tomentum. Sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face 15–18 mm (0.6–0.7 in) high, 35–40 mm (1.4–1.6 in) wide, projected into a beak about 1 cm (0.4 in) long, the surface brownish to blackish red. Sporangia in a single regularly shaped patch. **Habitat:** Karoo scrub, including the Addo and Uitenhage bush, all quite dry, desertlike areas, associated with cactoid euphorbias, *Strelitzia juncea,* and the introduced *Opuntia* prickly pear or beaver tail cactus. Rainfall averages 250–600 mm (10–24 in) annually, evenly distributed throughout the year. The climate is temperate with frost rare in winter, and temperatures may reach more than 40°C (104°F) in summer. **Distribution:** South Africa, Eastern Cape province, Port Elizabeth and Uitenhage districts.

Probably no other South African cycad is as well known as *Encephalartos horridus.* With its unusual color, spiny leaves curved backward and downward, and ease of horticulture, it has become one of the most popular species of the genus. This cycad is quite drought tolerant, and frost hardy to several degrees below freezing. In cultivation, it does best in well-drained soil and full sun to preserve its blue-gray leaf color. A waxy coating that reflects the heat and keeps water loss through the leaves to a minimum produces the color of the leaves.

Encephalartos horridus is usually considered a dwarf cycad because of its short leaves and apparently small stem. The major portion of the stem is usually subterranean, pulled into the ground by contractile roots, creating the illusion of a small plant. In some parts of its habitat, I have seen stems as tall as 1.2 m (3.9 ft), but stems that size are not common.

Encephalartos horridus varies considerably over its range, and a collection of the most divergent forms might lead to the impression of more than one species. Some of these specimens could easily be mistaken for *E. trispinosus* if based on leaves alone. When in cone, *E. horridus* can be easily separated from *E. trispinosus* by cone color. Cones of *E. horridus* are glaucous with a light coating of blackish brown tomentum whereas cones of *E. trispinosus* are greenish yellow. There is one form, the so-called dwarf *horridus,* that is fairly distinct. The female cones, seeds, even the leaves are smaller, easily distinguishing them from the normal *horridus.* These characteristics persist even in cultivation, so they are not produced by a difference of environment or soil conditions as some believe. There is one form from near Steytlerville that has leaves similar to those of *E. trispinosus* but the cones are definitely *E. horridus.*

Natural hybrids have been produced with *Encephalartos longifolius* (Plate 14). The resultant offspring favor *E. longifolius* in leaf length, leaf color, and stem growth. The large lobes on the leaflets clearly indicate *E. horridus* as a parent. Subsequent crossing of these hybrids, also occurring naturally, has produced a bewildering group of plants, some of which favor either one parent or the other. Trying to duplicate a natural hybrid with blue leaves instead of green, I produced basically the same hybrid except that I used a blue form of *E. longifolius* as the female parent. I was successful, and the resulting plants proved to be very decorative.

Reproduction of *Encephalartos horridus* in the wild is slow, in part the result of predation by a small weevil, *Antliarhinus zamiae,* whose larvae completely consume the endosperm of the seed, leaving only a hollow shell. Under normal conditions this would not have much effect on this species because the life span of an individual plant is so long. When coupled with destruction of populations through land clearance, illegal collecting, and predation by goats and porcupines, however, the outlook is not bright.

Encephalartos horridus does not seem to have insect pests of note except for a weevil whose larvae can attack the stem. The boreholes made by this pest allow the entry of fungus infections that can sometimes kill the entire plant. This insect does not seem to be a problem with plants in cultivation, except for those that were infected with it prior to planting. Many specimens of *E. horridus* I have seen in the wild have been badly damaged by porcupines. These animals eat into the stems, sometimes completely severing them from the rootstock. In some areas, plants are damaged by goats that feed on the soft emergent leaves and continue to eat down into the stem itself. Fungus infections enter through these damaged areas, and complete destruction of the plant often follows.

Under garden conditions, mature plants of *Encephalartos horridus* will cone with regularity, allowing the patient gardener to produce quantities of fertile seed. The seed can be germinated after about an 8-month ripening period, and the resulting plant is easily grown. Artificial propagation will, without doubt, be the salvation of *E. horridus* and most other cycad species.

Encephalartos horridus must be considered threatened. In the past, *E. horridus* was a common plant within its range, but this is no longer the case. Hundreds of plants have been illegally removed from their habitat in more recent years to supply the growing demand for this handsome cycad. Extensive areas where the cycads were once common no longer contain a single plant. The authorities have been unable to stop the illegal trade in *E. horridus,* and the plants are rapidly disappearing from their native lands. If this trend continues, *E. horridus* may be expected to disappear completely from the wild.

Encephalartos humilis I. C. Verdoorn 1951

PLATES 284–286

The epithet for *Encephalartos humilis* is Latin for lowly, referring to this cycad's small stature. **Stems** subterranean or to about 30 cm (12 in) above ground, the total length not exceeding 50 cm (20 in), 13–18 cm (5.1–7.1 in) in diameter, usually suckering from the base and forming small clumps, crown slightly woolly. **Leaves** usually five to eight in mature plants, curved backward and downward and slightly twisted, with a glaucous bloom when young, 30–50 cm (12–20 in) long, 11 cm (4.3 in) wide, moderately keeled above the middle of the leaf, grayish woolly in the juvenile state, losing this wool with age. Petiole 9–11 cm (3.5–4.3 in) long. Rachis markedly yellowish. Median leaflets 9–13 cm (3.5–5.1 in) long, 4–6 mm (0.2 in) wide, with about nine veins visible on the underside, abruptly reduced in length toward the base and sometimes slightly overlapping, margin entire and flat. **Female cones** solitary, barrel shaped, 25–30 cm (10–12 in) long, 8–10 cm (3.2–4 in) in diameter, the surface brownish gray woolly. Peduncle 3–5 cm (1.2–2 in) long and the cone often appearing sessile. Sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 20–23 mm (0.8–0.9 in) high, 38–41 mm (1.5–1.6 in) wide, projecting 12–15 mm (0.5–0.6 in), densely tomentose. Sarcotesta bright yellow to orange-yellow when ripe. Sclerotesta ovoid to globose, 28–34 mm (1.1–1.3 in) long, 21–25 mm (0.8–1 in) in diameter, somewhat three-sided, tan, more or less smooth with 17–25 darker, shallow longitudinal grooves. Chalaza 14–19 mm (0.6–0.7 in) long, 12–15 mm (0.5–0.6 in) wide. **Male cones** solitary, spindle shaped, 15–20 cm (6–8 in) long, 4–5 cm (1.6–2 in) in diameter, brownish gray woolly. Peduncle 10–12 cm (4–4.7 in) long. Sporophyll 5–25 mm (0.2–1 in) long, only slightly projecting. Sporophyll face 10 mm (0.4 in) high, 15–18 mm (0.6–0.7 in) wide, densely tomentose. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Grassland among sandstone rocks in mountainous areas, more recently under pine trees planted for lumber production. **Distribution:** South Africa, Mpumalanga province, Lydenburg, Carolina, and Nelspruit districts, restricted to the catchment area of the Crocodile River.

Encephalartos humilis in the early days was combined with *E. laevifolius* under *E. lanatus.* The first species to be separated from this complex was *E. laevifolius* in 1926 by Otto Stapf and Joseph Burtt Davy. In the late 1940s, Hugh Basil Christian, a botanist and plant collector, recognized that there was a third species contained within the *E. lanatus–E. laevifolius* complex. He conveyed this information to Inez Clare Verdoorn, a plant taxonomist interested in the cycads. After studying these plants in habitat, she found that there was, in fact, a third, distinct member of this complex and described *E. humilis* in 1951.

The closest relatives of *Encephalartos humilis* are *E. laevifolius* and *E. lanatus.* Distinguishing these three species is difficult because the differences are minor in immature or nonconing individuals. Generally, the three can be separated by leaf differences. *Encephalartos humilis* has short, slightly twisted leaves with a markedly yellow rachis, and median leaflets with 9 veins, whereas *E. lanatus* has leaves strongly curved backward and downward, with persistent tomentum, and median leaflets with 10–14 veins, and *E. laevifolius* has straight leaves and no tomentum. By a comparison of the details of leaf and stem, it should be possible to identify these three species, even without cones.

Even though *Encephalartos humilis* is the smallest species of the genus, it has not been very popular as a garden plant. This is doubtless the result of its usually deciduous habit. Annual loss of the leaf crown is common in cycads that inhabit grasslands that are normally burned off each year. This species has been observed, under proper conditions in cultivation, to maintain an almost permanent crown of leaves. It is easily grown if given a sunny location with good drainage. As with most dwarf species, the growth rate of *E. humilis* is not rapid. This cycad is tolerant of heat and frost and does equally well in the ground or as a pot plant.

Encephalartos humilis is definitely threatened. Much of its habitat has been converted to pine plantations. As the pines mature, less and less sunlight reaches the cycads. At some point they become dormant and eventually die. A rescue operation has been started to move these dying plants into a preserve, but regrowth has been disappointing. Seed is not often available, therefore propagation by this method is almost lacking.

Encephalartos inopinus R. A. Dyer 1964

PLATES 287, 288

The epithet for *Encephalartos inopinus* is derived from *inopinatus,* Latin for unexpected, referring both to this cycad's habitat, which is extremely dry and not typical for cycads, and Onverwacht, the name of the farm on which it was found and which also means unexpected. **Stems** slender, upright or leaning and decumbent with age, freely suckering from the base and sometimes forming large clumps, the primary stem generally 1–2 m (3.3–6.6 ft) tall but very old plants sometimes with decumbent stems to 6 m (20 ft) long, 15–25 cm (6–10 in) in diameter, the light gray stem surface with a characteristic patchwork appearance produced by a mixture of large and small leaf scars. Cataphylls lanceolate, about 4.5 cm (1.8 in) long, heavily tomentose. **Leaves** numerous, upright to spreading, 0.8–1.1 m (2.6–3.6 ft) long, 28–32 cm (11–13 in) wide, emergent leaves glaucous, lightly sprinkled with white hairs but soon glabrous. Rachis nearly straight, sometimes slightly upcurved and twisted toward the apex, sometimes flattened on the upper side toward the leaf base, rounded below, slightly grooved at the leaflet attachment. Petiole 10–20 cm (4–8 in) long, 12–14 mm (0.5–0.6 in) in diameter, with a light tan collar at its junction with the stem. Leaflets glabrous and glaucous, becoming green with age, above the middle of the leaf directed slightly upward and outward, curved slightly backward and downward and drooping, not overlapping, gradually reduced in size toward the slender, pungent leaf apex, median leaflets spreading at right angles from the rachis, those below directed slightly downward and more or less falcate, 14–21 cm (5.5–8.3 in) long, 8–13 mm (0.3–0.5 in) wide in the bottom third, above there gradually tapering toward the apex, spaced 1–2 cm (0.4–0.8 in) apart, 13–21 veins evident but not raised on the lower surface, abruptly reduced in size toward the base and ending in two to six prickles, margins flat and entire or rarely with one or two minute teeth on the lower margin near the leaf apex, directed slightly toward the apex. **Female cones** one to three, broadly subcylindrical, 30–35 cm (12–14 in) long, 15–20 cm (6–8 in) in diameter, slightly narrowing toward the apex, widest at the base. Peduncle 5–6 cm (2–2.4 in) long, stout, 5 cm (2 in) in diameter at the cone attachment and narrowed toward the base, covered with numerous linear, threadlike, tomentose bracts about the same length as the peduncle, giving the illusion that the cone is sessile. Sporophylls gradually increasing in size from bottom to top of the cone. Faces of median sporophylls 3 cm (1.2 in) high, 4–5 cm (1.6–2 in) wide, protruding about 1 cm (0.4 in), minutely and densely whitish tomentose, giving a silvery matte appearance to the terminal facet and the cone in general. Sarcotesta apricot colored when ripe. Sclerotesta 3.5–4 cm (1.4–1.6 in) long, 2–2.5 cm (0.8–1 in) in diameter, light tan, the surface almost smooth except for the numerous shallow and almost invisible longitudinal grooves. **Male cones** generally one to five, subcylindrical, usually leaning to one side, 18–25 cm (7.1–10 in) long, 6.5–8 cm (2.6–3.2 in) in diameter, narrowed toward both ends. Peduncle 6–16 cm (2.4–6.3 in) long, 2.5–3 cm (1–1.2 in) in diameter. Sporophyll face glaucous green, densely covered with small white papillae, giving a general light green matte appearance. Median sporophylls about 3 cm (1.2 in) long, at more or less right angles to the cone axis. Sporophyll face 5–8 mm (0.2–0.3 in) high, 17–20 mm (0.7–0.8 in) wide, with a deflexed beak 9–10 mm (0.4 in) long. Sporangia in a single regularly shaped patch. **Habitat:** Dry and desertlike areas in association with *Acacia, Aloe,* and *Euphorbia* on north-facing cliffs in hot, dry valleys, at elevations up to 1000 m (3300 ft). Rainfall averages 375–750 mm (15–30 in) annually, falling mostly in summer. **Distribution:** South Africa, Northern province, Lydenburg district, between Penge and Kromellenboog in the catchment area of the Olifants and Steelpoort Rivers.

Encephalartos inopinus was discovered by a group of hikers from the Lydenburg district in 1955. One of the group, Helmoed van Hoepen, collected a small offset from the plant and replanted it in his Johannesburg garden. Nine years later it was noticed by a visiting botanist, who reported it to Robert Allen Dyer at the Botanical Research Institute, Pretoria. At that time, Dyer and Inez Clare Verdoorn were conducting a cycad survey of South Africa. Dyer realized at once that here was a completely unknown species unlike any he had seen before. A group of botanists, including Dyer and Verdoorn, set off in August 1964 to try and rediscover this plant in its habitat. Unfortunately, the original plant was no longer there, but a second specimen was located on a nearby cliff above the Steelpoort River. Even though no cones had been located, Dyer published this new species later that year. Dyer thought that the discovery of a new species of *Encephalartos* at that time was unexpected. When he found that the name of the farm on which it grew was named Onverwacht, meaning unexpected in Afrikaans, it was no surprise when he named the species *inopinus,* from the Latin for unexpected.

Encephalartos inopinus is a remarkably beautiful and unusual cycad. The cones, stems, and leaves are so distinctive that it is all but impossible to confuse this species with any other South African cycad—unusual, too, that so distinctive a cycad should not have been discovered until 1955 or recognized as undescribed until 1964. This may have been the result of its occurrence in an area that would not normally be considered a good habitat for *Encephalartos* and because the remote, dry, rough terrain probably discouraged botanical exploration.

Strangely enough, there do not appear to be any close relatives of *Encephalartos inopinus* as none of the other

Transvaal cycads, or for that matter any of the African cycads, have similar characteristics. Dyer once told me that he thought the leaves resemble those of *Dioon spinulosum,* but the only similarity I can see is the gray-green color of the leaves and possibly the slender stems. Cladistic analyses done in the early 1990s suggest a closer affinity with the *E. eugene-maraisii* complex.

In cultivation, *Encephalartos inopinus* demands a sandy, well-drained soil and full sun. That growth is much more robust in cultivation than in habitat is evidenced by the larger diameter of the stems. This is probably the result of the availability of moisture all year long. The plants seem also to react well to applications of fertilizer through the growing season. Insect pests do not seem to be a problem as long as plants are kept in good health. Leaflets are smooth, flat, and covered with a waxy coating that seems to discourage scale insects and mealybugs. Once the plants are well established, they have a fairly rapid growth rate and will hold several sets of leaves if grown under optimum conditions. Reports indicate that 8–10 years elapse until cones are produced in cultivation.

Encephalartos inopinus has a very restricted habitat and cannot be considered common in any part of its range. It is found frequently in collections, and one can only surmise how many individuals may have been removed from the wild since its discovery. These poached plants have been sold or traded to both individual collectors and institutions over the years, in South Africa and abroad. From all reports it is not regenerating well in habitat and must therefore be considered endangered. For several years the Transvaal Provincial Administration Nursery near Pretoria raised seedlings of *E. inopinus* for sale to the public. For a short time this reduced some of the pressure on the wild populations. This nursery was later closed, leaving only poached plants to meet the demand for this species. In more recent years, many of the plants have been removed by the natives to be sold by the roadside to tourists. It is quite evident that the most stringent protection must be provided if this cycad is to survive in the wild. Small quantities of viable seed have been artificially produced, and it is hoped that this trend will continue. Several reports have been made of female cones of *E. inopinus* exploding before they were ripe. This condition, where the cones break open before maturing, is most probably the result of an excess of water being made available to a plant that comes from a desertlike environment. Whatever it is that causes this loss of cones, we must hope that a solution will be found to prevent it.

Encephalartos ituriensis Bamps & Lisowski 1990

PLATE 289

The epithet for *Encephalartos ituriensis* refers to the region of the Ituri Forest in the northeastern Democratic Republic of the Congo (Zaire), this cycad's habitat. **Stems** arborescent, erect or often leaning or decumbent in older and larger specimens, usually solitary but suckering from the base, eventually forming clumps, to 6 m (20 ft) tall, 50 cm (20 in) in diameter, crown covered with long, soft cataphylls. **Leaves** numerous, straight, bright green, 2–3 m (6.5–10 ft) long, 40 cm (16 in) wide, at first erect, then gradually spreading, emergent leaves with a coating of white tomentum, which is shed as the leaves mature. Petiole about 5 cm (2 in) long. Leaflets leathery, slightly twisted near the attachment and somewhat drooping from the rachis, to 25 cm (10 in) long and 3 cm (1.2 in) wide, margin with three to nine short spines and a pungent apex, basal leaflets reduced to spines. **Female cones** one or two, erect, cylindrical ovoid, about 20 cm (8 in) long and about 12 cm (4.7 in) in diameter, at first apple green, turning tan to yellow at maturity, glabrous. Peduncle about 3–4 cm (1.2–1.6 in) long, stout. Median sporophylls 4.5–5 cm (1.8–2 in) wide, 2–2.5 cm (0.8–1 in) high, with a somewhat sunken terminal facet, the exposed surface yellowish tan and the internal surface red. Sarcotesta dark red when ripe. Sclerotesta 2.5–3.5 cm (1–1.4 in) long, 1.5–2.5 cm (0.6–1 in) in diameter. **Male cones** two to four, semipendent, spindle shaped, about 26 cm (10 in) long and 7 cm (2.8 in) in diameter, tapering toward both ends, tan to yellow at maturity. Peduncle stout, to 16 cm (6.3 in) long and 1.8 mm (0.7 in) in diameter. Sporophylls about 3 cm (1.2 in) long. Sporophyll face 6–9 mm (0.2–0.4 in) high, 25–30 mm (1–1.2 in) wide, the facets distinct and glabrous. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Exposed positions on steep slopes in grassy savanna or on granite domes at the fringes of rain forest, recorded at elevations of 1000–1200 m (3300–3900 ft). **Distribution:** Democratic Republic of the Congo (Zaire), Ituri Forest area in the northeastern corner of the country.

Walter Robyns (1948) reported the occurrence of *Encephalartos laurentianus* from Ituri, Zaire, based on a sterile collection, that is, one without cones. In April 1976, Stanislaw Lisowski collected specimens of an *Encephalartos* in the vicinity of Nduyer, Zaire, located about 50 km (30 miles) north of Mambasa. The cycad was growing on large granite domes that emerge from the surrounding rain forest, in an area inhabited by the Bambuti pygmies. At that time the cycads were provisionally identified as *E.*

hildebrandtii. The habitat was revisited later by Lisowski and Paul Bamps, and it was determined that the Ituri cycad was an undescribed species. In 1987, Bamps and Lisowski presented a paper on the new species at the first symposium on cycad research, Cycad 87, at Nice, France. The proceedings of this meeting were published in 1990, including the description of *E. ituriensis.*

Although *Encephalartos ituriensis* might be mistaken for *E. hildebrandtii, E. laurentianus,* or *E. whitelockii,* it differs in leaflets and cones. Length and width of median leaflets in these four species are as follows: *E. ituriensis* 25 × 3 cm (10 × 1.2 in), *E. hildebrandtii* 35 × 4.5 cm (14 × 1.8 in), *E. laurentianus* 35–50 × 4–7 cm (14–20 × 1.6–2.8 in), *E. whitelockii* 30 × 2.5 cm (12 × 1 in). The apex of the leaflet in *E. ituriensis* and *E. whitelockii* has a single spine whereas *E. hildebrandtii* and *E. laurentianus* have two or three spines. Female cones vary in color: *E. ituriensis* yellow-brown, *E. hildebrandtii* dull yellow, *E. laurentianus* yellow with an overlay of red-brown tomentum, *E. whitelockii* greenish yellow.

I have no information on the cultivation of *Encephalartos ituriensis* over the long term. There are few seedlings or specimens of this species in cultivation. In 1985 a small amount of seed became available, and the resulting seedlings have grown quite well. There is no reason to believe that *E. ituriensis* will be difficult to grow. It will no doubt require a subtropical to tropical climate and plenty of moisture. Because of its large size, it would not be a good cycad where space is a problem.

Encephalartos ituriensis and its conservation status are not adequately known. Since the habitat of *E. ituriensis* is in a remote section of Zaire, requiring considerable time over very poor roads to gain access to it, this will no doubt help keep collecting pressures to a minimum. There is insufficient information to define the conservation status of *E. ituriensis.*

Encephalartos kisambo Faden & Beentje 1989 (March)

PLATES 290, 291

Encephalartos voiensis Moretti, De Luca, Sclavo & D. W. Stevenson 1989 (August)

The epithet for *Encephalartos kisambo* is the local name for this cycad in Kenya in the Taita language. Stems arborescent, erect or leaning in larger specimens, usually solitary, rarely suckering from the base to form clumps, 0.9–2.2 m (3–7.2 ft) tall, 45–52 cm (18–20 in) in diameter, the leaf scars rhomboid, 5–7.5 cm (2–3 in) high, 12.5–15 cm (5–6 in) wide. Cataphylls linear to linear lanceolate, 8–14 cm (3.2–5.5 in) long, about 1.5 cm (0.6 in) wide, generally dark brown tomentose below and glabrous above. Leaves numerous, upright, then gradually spreading, more or less straight and rigid, 2.4–3.6 m (7.9–12 ft) long, 51–76 cm (20–30 in) wide, emergent leaves with considerable light brown hair that is soon shed. Petiole 2.5–5 cm (1–2 in) long, 2.5–7.5 cm (1–3 in) in diameter, swollen at the base, which is usually tomentose with matted brown hairs but may also be glabrous. Leaflets in 89–96 pairs, in mature plants gradually reduced to spines toward the base, abruptly reduced in immature plants, median leaflets more or less crowded and overlapping, lanceolate oblong, falcate, 24–37.5 cm (9.4–15 in) long, 29–37 mm (1.1–1.5 in) wide, spaced 2.5–3 cm (1–1.2 in) apart, leathery, with a pungent apex, margins revolute, the upper margin with three to five spines to 1 cm (0.4 in) long, all within 7 cm (2.8 in) of the base of the leaflet and usually on a lobelike extension, the lower margin unarmed or with a single spine below the midpoint of the leaflet, leaflets of immature plants with additional spines that disappear as the plant matures. Female cones one to five, upright, cylindrical to ovoid cylindrical, 42–60 cm (16–24 in) long, 16–20 cm (6.3–8 in) in diameter, yellow to orange at maturity, glabrous or lightly tomentose. Peduncle 11–15 cm (4.3–6 in) long, 5–7 cm (2–2.8 in) in diameter, densely covered with dark brown tomentum. Sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face rhomboid, 15–22 mm (0.6–0.9 in) high, 35–48 mm (1.4–1.9 in) wide, projecting 24 mm (0.9 in), generally smooth toward the margins. Sarcotesta orange-yellow when ripe. Sclerotesta ellipsoid, 30–39 mm (1.2–1.5 in) long, 17–29 mm (0.7–1.1 in) in diameter, tan, with 11–12 longitudinal ridges. Chalaza 7–11 mm (0.3–0.4 in) long, 5–8 mm (0.2–0.3 in) wide. Male cones one to several, sometimes curved, cylindrical to long conical, 49–64 cm (19–25 in) long, 10–12.5 cm (4–5 in) in diameter, creamy yellow at maturity. Peduncle 15–32 cm (6–13 in) long, 3.5–4.5 cm (1.4–1.8 in) in diameter, moderately to densely covered with dark brown tomentum. Median sporophylls 3–4 cm (1.2–1.6 in) long, more or less at right angles to the cone axis. Sporophyll face triangular to rhomboid, 11–14 mm (0.4–0.6 in) high, 20–27 mm (0.8–1.1 in) wide, deflexed, truncate, glabrous. Sporangia in a single patch. Habitat: Low-growing, moist, evergreen, mist forest composed of many epiphytes and few understory plants, in granitic soils, with preferred exposures the summit and southeastern and eastern slopes, occasionally found on exposed steep slopes in dry bushland, at elevations of 800–1800 m (2600–5900 ft). Distribution: Kenya, originally known only from a very small area of about 160 hectares (400 acres) in the Maungu Hills near Voi in the southern part of the country, also reported from the Milionyi, Nyangala, Sagala, and Kasigau hills. The type specimen of *Encephalartos voiensis* (= *E. kisambo*) was collected on Mount Kasigau.

Encephalartos kisambo is a remarkably handsome cycad, reputed to have been discovered not far from the city of Voi, Kenya, in 1970 by Robert Archer, an American working at the East African Herbarium, Nairobi. It was known till its description as *E.* "Voi," Archer's cycad, or Heenan's *Encephalartos* "B." In 1989 it was described as *E. kisambo* and shortly thereafter as *E. voiensis,* but *E. kisambo* has priority. Whatever it is called, there is no doubt as to its beauty.

The first material of what was to be *Encephalartos kisambo* that I was able to study was sent to me by John J. Lavranos in 1973, shortly after its discovery. It consisted of herbarium specimens of the petiole, central portion of the leaf, and leaf apex. What most impressed me about this material were the spiny lobes on the upper edge of the leaflets and the diameter of the petiole. At the time, I felt that the leaflet lobes resembled the spiny lobes on immature leaves of *E. woodii* and that there might be a relationship between the two plants. In later years it became apparent that the two species are not at all closely related. This is an illustration of the problem of working with herbarium specimens and not with living plants in the wild or in cultivation.

The habitat of *Encephalartos kisambo* is said to be rich in plant life, especially epiphytes. At least four kinds of epiphytic plants (*Davallia, Impatiens, Streptocarpus,* and orchids) have been observed growing on the stems of this cycad.

Encephalartos kisambo is fast growing, has some frost tolerance, and is easy to grow. Established specimens tend to retain several heads of leaves, all in good condition, thereby forming an exceptionally decorative cycad. It is not common in cultivation, and normally no more than a single specimen is grown, generally because of its large size. In 1993 a large amount of viable seed was introduced from the wild and distributed worldwide. This introduction has firmly established *E. kisambo* in cultivation and will no doubt ensure its continued existence in collections, both public and private.

The conservation status of *Encephalartos kisambo* is not adequately known. The size of the known habitat is quite small and collectors have removed considerable numbers of cycads in more recent years. Also, the local natives are rapidly denuding the hills for the lucrative charcoal trade. So this species has been given the status of vulnerable, possibly endangered.

Encephalartos laevifolius Stapf & Burtt Davy 1926

PLATES 292–295

The epithet for *Encephalartos laevifolius* is derived from *laevis,* Latin for smooth, and *folium,* leaf, referring to the smooth and glabrous leaves. **Stems** arborescent, erect, solitary or freely suckering from the base, 1–3.5 m (3.3–11.4 ft) tall, 25–35 cm (10–14 in) in diameter, usually with a ringed appearance from the differences in growth from one season to the next, with little or no wool on the stem or in the crown. Cataphylls alternate, very prominent in the crown, about 6 cm (2.4 in) long and 2 cm (0.8 in) wide. **Leaves** numerous, straight or slightly recurving and sometimes twisted in the upper half, glaucous, usually held at an angle of about 90° to the crown, horizontally, to 1 m (3.3 ft) long, 16–20 cm (6.3–8 in) wide, moderately keeled, in the juvenile stage with a short, dense, woolly covering except on the underside of the leaflets. Petiole terete, 22–25 cm (8.7–10 in) long. Leaflets crowded but not overlapping or only slightly so, pungent, median leaflets 12–15 cm (4.7–6 in) long, 5–8 mm (0.2–0.3 in) wide, rarely as wide as 10 mm (0.4 in), with 10–12 veins on the lower surface, margin entire and flat with only an apical spine. **Female cones** one to five, barrel shaped, 20–30 cm (8–12 in) long, 10–15 cm (4–6 in) in diameter, light yellow, apex rounded. Peduncle 4–5 cm (1.6–2 in) long but hidden among the cataphylls, the cone appearing sessile. Sporophylls with the terminal facets flattened and not very prominent, densely covered with short white or pale brown hairs, making it appear lighter in color than the glabrous areas, median sporophylls 4 cm (1.6 in) long. Sporophyll face about 2 cm (0.8 in) high and 4.5 cm (1.8 in) wide, flattened and not projecting. Sarcotesta orange-yellow when ripe. Sclerotesta more or less three-sided, 25–30 mm (1–1.2 in) long, 18–20 mm (0.7–0.8 in) in diameter, light tan, smooth. **Male cones** one to five, curved during pollen shedding, subcylindrical, 30–40 cm (12–16 in) long, 9–10 cm (3.5–4 in) in diameter, tapering slightly toward apex and base, light yellow or white tomentose, brown with age. Peduncle 3–4 cm (1.2–1.6 in) long but hidden by the cataphylls, the cone appearing sessile. Median sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face 13 mm (0.5 in) high, 34–36 mm (1.3–1.4 in) wide, the beak projecting about 1 cm (0.4 in). Sporangia in a single patch. **Habitat:** Exposed rocky outcrops among grasses and small shrubs at elevations of 1300–1800 m (4300–5900 ft). Rainfall averages 1250 mm (49 in) annually. Temperatures range from a high of 40°C (104°F) in summer to severe frosts in winter. **Distribution:** South Africa, Nelspruit district, Kaapsehoop Mountains in the catchment area of the Crocodile River, and at Mariepskop in the Drakensberg, both in Mpumalanga province, also the Tugela Ferry district and an undisclosed area near the sea in KwaZulu-Natal province. Swaziland, Piggs Peak area.

The original specimen of *Encephalartos laevifolius* was collected by W. Todd about 1920 and was chosen as the type by Otto Stapf and Joseph Burtt Davy when the species was described in 1926. John Hutchinson and George Rattray (1933) placed *E. laevifolius* in synonymy under *E. lanatus.* Murray Ross Henderson (1945) reestablished *E. laevifolius* as a separate species, a decision accepted by all taxonomists subsequently researching *Encephalartos.*

Encephalartos laevifolius is most closely related to two other Mpumalanga species, namely, *E. humilis* and *E. lanatus.* These species and *E. friderici-guilielmi* from the Eastern Cape are the only cycads that might cause confusion with *E. laevifolius* in identification. Lack of wool in the crown and more or less straight glabrous leaves would be the primary features to look for in the absence of cones to identify *E. laevifolius.*

There are two distinct forms of *Encephalartos laevifolius* in the Northern province, one green (Mariepskop form; Plates 292, 293), the other with silvery leaves (Kaapsehoop form; Plates 294, 295). Differences in cones have also been noted, and additional botanical investigation must be carried out to clarify the relationships of the two forms. More recently, three other populations have been found. One is from the Tugela Ferry district in KwaZulu-Natal and has cones distinctly different from those of the type. Another occurs near the Havelock Mine at Emlembe, Swaziland. The last and most recently discovered population is from an undisclosed habitat (for conservation reasons) in KwaZulu-Natal, close to the sea.

At one time an odd plant was collected in the area of Piggs Peak, Swaziland, that was said to appear like a hybrid between *Encephalartos laevifolius* and *E. paucidentatus.* I know of no other reports of possible hybridization of *E. laevifolius,* either natural or artificial.

Encephalartos laevifolius is a robust plant with tall, slender stems and silvery leaves. This cycad transplants well and poses no problems in horticulture if given well-drained soil and a sunny location. It is relatively fast growing when provided with sufficient water and fertilizer during its periods of active growth. *Encephalartos laevifolius* exhibits a somewhat deciduous growth pattern, old leaves usually dying before new leaves emerge. For this reason, *E. laevifolius* generally holds one head of leaves at a time, in contrast to other species that may hold as many as three or four. When in good leaf, this species is one of the most handsome of the genus. Seed is not commonly available, so most plants in cultivation have been wild collected.

Encephalartos laevifolius, though a very attractive cycad, is not often encountered in botanical gardens. Although it was not a rare cycad in its early history, the collection of plants from habitat for garden culture, plus the fact that large areas of its range have been cleared for pine plantations, have drastically reduced its numbers in the wild. *Encephalartos laevifolius* must be considered endangered, making its propagation from seed of immediate importance.

Encephalartos lanatus Stapf & Burtt Davy 1926

PLATES 296, 297

The epithet for *Encephalartos lanatus* is Latin for woolly, referring to the woolly covering of the crown, juvenile leaves, and cones. **Stems** arborescent, erect to reclining, unbranched or suckering from the base, usually to 1 m (3.3 ft) tall, rarely as long as almost 3 m (10 ft) but at this size generally reclining, 20–25 cm (8–10 in) in diameter. **Leaves** numerous, 60–95 cm (24–38 in) long, 12.5 cm (5 in) wide, moderately keeled, curved or bowed, or with the apex curved backward and downward, and somewhat twisted, white or grayish woolly in the juvenile stage except for the underside of the leaflets. Petiole 12–19 cm (4.7–7.5 in) long, 8 mm (0.3 in) in diameter. Leaflets with a light gray bloom when young, turning dark green with age, overlapping in an upward direction, with an apical spine, basal leaflets reduced in size but not to prickles, median leaflets 10–13 cm (4–5.1 in) long, 6–8 mm (0.2–0.3 in) wide, margins flat and entire. **Female cones** one to four, barrel shaped, 20–35 cm (8–14 in) long, 12–15 cm (4.7–6 in) in diameter, densely covered with a light tan tomentum. Peduncle 2–3 cm (0.8–1.2 in) long but the cone often appearing sessile. Sporophyll face 25–27 mm (1–1.1 in) high, 43–50 mm (1.7–2 in) wide, only slightly protruding. Sarcotesta yellow to brown when ripe and very thin. Sclerotesta ovoid to globose, somewhat three- or four-sided, 24–30 mm (0.9–1.2 in) long, 21–25 mm (0.8–1 in) in diameter, surface smooth with 7–11 very indistinct longitudinal grooves. Chalaza 13–17 mm (0.5–0.7 in) long, 9–13 mm (0.4–0.5 in) wide, deeply pitted. **Male cones** one to four, more or less cylindrical, 25–30 cm (10–12 in) long, 5–6 cm (2–2.4 in) in diameter, densely covered with a light tan to grayish tomentum. Peduncle when visible only 3–5 cm (1.2–2 in) long, the cone often appearing sessile. Sporophylls 23–32 mm (0.9–1.3 in) long. Sporophyll face flat, 10–14 mm (0.4–0.6 in) high, 18–25 mm (0.7–1 in) wide, only slightly projecting, the facets indistinct because of a heavy tomentum. Sporangia in a single somewhat butterfly-shaped patch. **Habitat:** Sheltered valleys, usually on rock outcrops in open areas, in deep, sandy, fertile soil, at elevations averaging 1500 m (4900 ft). Rainfall averages 660–770 mm (26–30 in) annually, falling mainly in summer. Temperatures in summer are high, sometimes reaching 40°C (104°F); winters are dry and severe frosts occur. Most of the range is subjected to yearly grass fires. **Distribution:** South Africa, Gauteng and Mpumalanga provinces, in the catchment areas of the Wilge, Olifants, and Little Olifants Rivers of Middelburg, Witbank, and Bronkhorstpruit districts.

The cycad that was to become *Encephalartos lanatus* was first documented in 1911 by O. C. Weeber of the Transvaal (now Mpumalanga) Department of Agriculture. He mistakenly identified the plant as *E. friderici-guilielmi* and it was not until 1926 that Joseph Burtt Davy, also of the Transvaal Department of Agriculture, recognized *E. lanatus* as distinct. In the same publication, Otto Stapf and Burtt Davy described *E. laevifolius,* another Transvaal species somewhat similar to *E. lanatus.* Then, John Hutchinson and George Rattray (1933) lumped the two together under the name *E. lanatus.* Murray Ross Henderson (1945), revising the genus *Encephalartos,* reexamined this issue and, after considering differences in cone and leaf morphology, once again separated *E. lanatus* and *E. laevifolius.* The two species are now well accepted by cycad taxonomists.

Encephalartos lanatus grows in a rocky grassland habitat that is usually subjected to annual burning. In spite of this, regeneration is good and the older plants do not seem to suffer too much stress. Fire damage is usually limited to loss of leaves, blackening of the stems, and destruction of the seed crop. Older, leaning specimens suffer most, where the heat from the fires damages the underside of the stem. After several years, the fire damage will weaken the stem until it collapses and the plant dies. Even in such cases, offsets usually develop at the base of the damaged stem and the rootstock lives on.

With its small, compact crown of gray leaves gracefully curved backward and downward, *Encephalartos lanatus* makes a fine garden subject. On the other hand, this cycad is one of the most difficult to transplant from the wild and many attempts have ended in failure. The few that do survive develop slowly into fine specimens that are both drought and frost tolerant. Seed germinates easily, though the resultant seedlings are very slow growing. *Encephalartos lanatus* does best in full sun and when planted in sandy, well-drained soil. In the Northern Hemisphere it takes the change from summer to winter rainfall without any apparent ill effects.

Although once very common in parts of its range, *Encephalartos lanatus* has been drastically reduced in numbers as a result of commercial collecting. Its conservation status is listed as vulnerable in *Threatened Plants of Southern Africa* (Hall et al. 1980). The large stands of *E. lanatus* in the area of Botshabelo, Mpumalanga, have been proclaimed as a preserve by the Middelburg Town Council and receive protection.

Encephalartos latifrons Lehmann in de Vriese 1838

PLATES 298, 299

Encephalartos horridus f. *latifrons* (Lehmann) Miquel 1838, *E. horridus* var. *latifrons* (Lehman) Miquel 1842

The epithet for *Encephalartos latifrons* is derived from *lati-*, Latin for broad, and *frons,* frond, referring to the wide leaflets, not leaves; *latifoliolatus,* wide leaflet, might have been a better choice. **Stems** arborescent, erect, unbranched, often forming a clump because of offsets arising from the base, 2.5–3 m (8.2–10 ft) tall, rarely as tall as 4.5 m (15 ft) though even large stems upright and not decumbent, 30–45 cm (12–18 in) in diameter, crown containing wool usually only before leaf production. **Leaves** numerous, stiff, curved either slightly or strongly backward and downward in the upper third to half of the leaf, rarely curved or bowed, 1–1.5 m (3.3–4.9 ft) long, 12–17 cm (4.7–6.7 in) wide, moderately to strongly keeled, dark green with a yellowish rachis. Petiole 10–20 cm (4–8 in) long, 12–15 mm (0.5–0.6 in) in diameter. Leaflets broad, rigid, on the rachis in a V formation that becomes narrower toward the apex of the leaf, basal leaflets reduced and pricklelike, median leaflets 10–15 cm (4–6 in) long, 4–6 cm (1.6–2.4 in) wide, 1.5–2 cm (0.6–0.8 in) wide at the attachment to the rachis, the veins prominent on the lower surface, the upper margin usually entire but rarely with one spine or lobe, the lower with two to four triangular lobes twisted out of the leaflet plane, the lobes forming an interlocking pattern characteristic of this species. **Female cones** one to three, erect, barrel shaped, 50–60 cm (20–24 in) long, 23–25 cm (9.1–9.8 in) in diameter, dark olive green. Peduncle short, cone appearing sessile. Sporophylls 8–8.5 cm (3.2–3.3 in) long. Sporophyll face 3–3.5 cm (1.2–1.4 in) high, 4–4.5 cm (1.6–1.8 in) wide, projecting 2–2.5 cm (0.8–1 in), deeply wrinkled, pimply. Sarcotesta red when ripe. Sclerotesta ovoid to subglobose, 25–31 mm (1–1.2 in) long, 20–21 mm (0.8 in) in diameter, light brown with 12–15 light tan ridges. Chalaza prominent, tan, 14–17 mm (0.6–0.7 in) long, 12–13 mm (0.5 in) wide, shallowly pitted. Male cones one to three, subcylindrical, 30–50 cm (12–20 in) long, 8–17 cm (3.2–6.7 in) in diameter, narrowed toward both ends, dark olive green. Peduncle about 4 cm (1.6 in) long and 4.5 cm (1.8 in) in diameter, usually hidden among the cataphylls, the cone appearing sessile. Sporophylls 5.5–7 cm (2.2–2.8 in) long. Sporophyll face 1–1.5 cm (0.4–0.6 in) high, 3–3.5 cm (1.2–1.4 in) wide, with a prominent beak 2 cm (0.8 in) long, ending in an irregularly truncate terminal facet, the sporophyll surface slightly ribbed. Sporangia in a single regularly shaped patch not quite extending to the edge of the sporophyll. Habitat: Scrub vegetation on rocky outcrops in flat country and on steep hillsides. Rainfall averages 1000–1250 mm (39–49 in) annually, evenly distributed throughout the year. Summers are hot and dry, and no frost occurs in winter. Distribution: South Africa, Eastern Cape province, Bathurst and Albany districts, the distribution now extremely limited and the plant so rare that it is all but extinct in the wild.

Encephalartos latifrons is one of the most majestic of the South African cycads. Its tall stem, crowned by numerous dark green leaves curved backward and downward, at one time made it a spectacular sight in the Trapps Valley area of the Bathurst district of the Eastern Cape. I consider myself very lucky to have been able to study this plant while there were still individuals left in the wild. This species is definitely one of the rarest and most desirable of the South African cycads, and this has led to its almost complete extinction in its natural habitat.

The closest relative of *Encephalartos latifrons* is *E. arenarius.* The habitats of these two species are not widely separated but are quite different. *Encephalartos latifrons* grows on rocky outcrops in relatively flat country, *E. arenarius* on the steep sides of coastal stabilized sand dunes. The two species are easily identified using only their leaves. The leaves of *E. latifrons* are dull to shiny dark green and the leaflets closely spaced, overlapping, and interlocking whereas those of *E. arenarius* are dull to glaucous green and widely spaced. If cones are present, the species are also easily identified because *E. latifrons* has olive green cones with sporophylls distinctly wrinkled and pimpled whereas *E. arenarius* has light green cones with a smooth sporophyll.

There are two forms of *Encephalartos latifrons,* one from the Trapps Valley area, the other from the Green Hills area. The Trapps Valley form has short, broad, tightly interlocking leaflets held in a tight V formation on the rachis, a leaflet length to width ratio of 2 to 1, and a petiole that is flattened above and angular below. The Green Hills form has leaflets that are more spreading, a leaflet length to width ratio of 3 or 4 to 1, looking more like the leaflet shape of *E. arenarius,* and a petiole that is almost round; in all other respects it is definitely *E. latifrons.* Cones of the Green Hills form do not seem to differ from those of the Trapps Valley form.

I have seen several larger plants that seem to be interspecific hybrids. One such hybrid probably has *Encephalartos altensteinii* as the other parent. The other *E. latifrons* hybrids are more obscure, and any attempt to name the other parent would be no more than a guess. One quality these hybrids have in common is that they are all very beautiful plants and worthy of a place in any garden.

Encephalartos latifrons is well known for its slow rate of growth. New leaves are only produced every 2–3 years, and cones are seldom seen. I have two plants that have added only 30 cm (12 in) of stem height in 20 years of cultivation. This growth rate would have probably been much slower in the wild. It seems that seedlings will grow quite rapidly if given the proper conditions, and I have seen grapefruit-sized plants produced in as little as 10 years.

Regeneration of *Encephalartos latifrons* in the wild has probably not taken place for many years. When I visited Trapps Valley for the first time in 1965, no seedlings or smaller plants were seen. More recent reports indicate that almost all the adult plants have been removed, even the largest ones. It now appears that the only hope for this species is artificial fertilization of cones when they are produced on cultivated plants. This beautiful cycad is worth whatever time and effort is required to increase its numbers.

Encephalartos latifrons is easy to cultivate and takes no special care. As with most cycads, it must have good drainage and does best when grown in full sun. Plants in my garden have been exposed to temperatures as low as −4°C (25°F) without damage to the leaves. The only insect pests that seem to infest this cycad are scale insects, but they are generally not a problem unless the plant is stressed by growing in too much shade.

The conservation status of *Encephalartos latifrons* is one of the most precarious of all the South African species. It has never been abundant and as early as 1916 the director of the Kirstenbosch National Botanical Garden, Henry

Harold Welch Pearson, wrote, "This species seems to be on the verge of extinction. It is only known to occur in two localities, in which the plants are now very hard to find." This opinion was repeated by Charles J. Chamberlain (1919) in *The Living Cycads* when, after a visit to the *E. latifrons* habitat in 1912, he wrote, "Field studies are laborious, since the plants are isolated, usually half a mile or even a mile [0.8–1.6 km] apart." In 1965 the late Bruce Bursey, owner of the Lowlands Nursery in the Eastern Cape, wrote to me, "*E. latifrons* is widely scattered in habitat, so much so that no viable seed is produced as the male and female plants are too far apart." It is generally agreed that no seed production has occurred in habitat in recent history. Evidence of this is the complete lack of seedling plants in the wild. In the 1980s and 1990s some seed was produced on garden plants, but the number of viable seeds is still pitifully small. *Encephalartos latifrons* must be considered extremely endangered, nearly extinct in its habitat.

Encephalartos laurentianus De Wildeman 1903

Encephalartos laurentianus, named in honor of Émile Laurent (1861–1904), who first introduced plants of this species from the Belgian Congo, now the Democratic Republic of the Congo (Zaire), to Belgium, is called *bundu-nquma* by the Malele tribe. Stems at first erect, then in older and larger specimens decumbent and serpentine, rarely branched, to 15 m (49 ft) long or longer, 60–70 cm (24–28 in) in diameter, grayish to ivory white, exhibiting large and prominent scars of old leaves. Leaves numerous, erect, then spreading, linear oblong, 4–7 m (13–23 ft) long, 50–90 cm (20–36 in) wide, tapering gradually toward the base, apex rounded. Petiole 30–40 cm (12–16 in) long and more or less three-sided. Rachis keeled above and rounded below, the rachis and swollen petiole base densely covered at first with grayish tomentum. Leaflets in about 120 pairs, basal leaflets gradually reduced to spines 3–4 cm (1.2–1.6 in) long that terminate 30–40 cm (12–16 in) above the swollen petiole base, median leaflets unequally linear lanceolate, thin and flexible, falcate, 35–50 cm (14–20 in) long, 4–7 cm (1.6–2.8 in) wide, apex acuminate and pungent, sometimes three-toothed, margin slightly curved backward and downward, with 9–15 spreading or forwardly directed spines 3–10 mm (to 0.4 in) long that are more or less evenly distributed, leaflet attachment 8–10 mm (0.3–0.4 in) wide, the base with upper margin rounded and lower margin straight. Female cones usually two to four, ellipsoid to oblong ovoid, 35–45 cm (14–18 in) long, 20–21 cm (8–8.3 in) in diameter, at first greenish yellow, bright yellow when mature, apex rounded, base truncate. Peduncle short, 7–8 cm (2.8–3.2 in) in diameter, more or less smooth with a covering of dark reddish tomentum. Sporophyll face about 3.5 cm (1.4 in) high and 7 cm (2.8 in) wide, densely reddish brown tomentose, upper facets distinct, lower ones not. Sarcotesta bright red to reddish orange when ripe. Sclerotesta short to long ovoid, 40–50 mm (1.6–2 in) long, 24–28 mm (1–1.1 in) in diameter, the surface smooth except for 10–13 indistinct longitudinal ridges. Male cones usually two to six, rarely as many as eight, ellipsoid to subconical, 17–35 cm (6.7–14 in) long, 6–10 cm (2.4–3.9 in) in diameter. Peduncle 25–30 cm (10–12 in) long, 4–5 cm (1.6–2 in) in diameter, red tomentose with scattered scales toward the top. Median sporophylls 10–13 mm (0.4–0.5 in) high, 18–25 mm (0.7–1 in) wide, reddish tomentose. Sporophyll face trapezoidal, more or less flat, the terminal facet sunken and with a covering of reddish brown tomentum, the upper and lower facets indistinct and glabrous. Sporangia in a single somewhat irregularly shaped patch. Habitat: Sloping riverbanks under dense, humid, gallery forest, also in open sunny areas on red sandstone cliffs. Rainfall averages 1500–2000 mm (59–79 in) annually. Temperatures average above 20°C (68°F) in January, and 20–30°C (68–86°F) in July. Distribution: Democratic Republic of the Congo (Zaire) and Angola, valley of the Kwango River, which forms a part of the boundary between the Bandundu region of southwestern Zaire and northern Angola. *Encephalartos laurentianus* is frequent from the Kwango's confluence with the Fufu southward to its junction with the Kikasu River, and from the many smaller tributary valleys on both sides of the Kwango in the two countries.

Encephalartos laurentianus is the largest and most majestic of the living cycads. In overall length of stem it might be surpassed by *Lepidozamia hopei* and some of the *Cycas* species of the South Pacific islands, but in stem girth and leaf length it is unsurpassed. Upright stems of *E. laurentianus* seldom exceed 10 m (33 ft) in height, but decumbent specimens have been reported more than 15 m (49 ft) long. These huge stems are crowned by numerous dark green, arching leaves, often reaching 7 m (23 ft) in length.

During the first half of the twentieth century there were numerous European and American botanists exploring central Africa. These explorations disclosed the presence of two other large *Encephalartos,* one in northeastern Zaire, another in western Uganda. For approximately 40 years they were presumed to be widely disjunct populations of *E. laurentianus.* After more intensive study, they proved to be distinct species: *E. ituriensis,* described in 1990 from the Ituri Forest in northeastern Zaire, and *E. whitelockii,* described 5 years later from the Mapanga River in western Uganda.

Encephalartos laurentianus is not common in collections, either public or private. One of the reasons for this may be the space necessary to grow this species. The other, possibly more important reason is the difficulty in traveling safely to its habitat and the problems involved in exporting the plants. Since Zaire, formerly the Belgian Congo, was at one time a colony of Belgium, it is not surprising that a number of specimens are to be found in Belgian botanical gardens. The botanical gardens at Brussels house seven specimens of this beautiful and imposing cycad. In more recent years, successful attempts at artificial pollination have been rewarded with viable seed that is possibly the first propagation material of *E. laurentianus* available since 1907. It is hoped that more of these seeds will find their way into the collections of botanical gardens and private parties situated in areas where plants may be grown outdoors.

In cultivation, *Encephalartos laurentianus* does not seem to pose many problems. It has basically been maintained under conservatory conditions in Europe and will require subtropical to tropical conditions when grown outdoors. A few of the seedlings produced in Belgium have found their way to Florida and southern California. It will be some time before their adaptability to these areas can be properly assessed.

Based on the information available, *Encephalartos laurentianus* should be considered as not threatened. The habitat is not useful as agricultural land, and the cycads themselves, according to informed reports, have no economic value to the inhabitants of the area.

Encephalartos lebomboensis I. C. Verdoorn 1949b

PLATES 6, 300, 301

The epithet for *Encephalartos lebomboensis* refers to the Lebombo Mountains in northeastern South Africa, the type locality for this species. STEMS rarely branched but often suckering from the base, to 4 m (13 ft) long, 25–30 cm (10–12 in) in diameter, with a somewhat woolly crown. Cataphylls densely tomentose below and glabrous above, long triangular, about 4 cm (1.6 in) long, 1 cm (0.4 in) wide at the base. LEAVES numerous, spreading, varying from light to dark green depending on habitat, moderately lighter below than above, 1–1.5 m (3.3–4.9 ft) long, 20–27.5 cm (8–11 in) wide at midleaf, more or less straight but in some cases curved slightly backward and downward at the tip, flat or shallowly keeled, emergent leaves densely tomentose but soon glabrous. Petiole 3–10 cm (1.2–3.9 in) long, 2–3 cm (0.8–1.2 in) in diameter, rounded above and below. Rachis golden green. Basal leaflets reduced to prickles, median leaflets 12–18 cm (4.7–7.1 in) long, 12–22 mm (0.5–0.9 in) wide, usually attached at a slight angle and overlapping in a downward direction, margins with a thickened rim, rarely entire or armed with one to four spines on the upper and lower margins but more often the lower, the spines usually lining up in almost straight rows down the length of the leaf. FEMALE CONES usually solitary, rarely two, erect, ovoid to barrel shaped, 40–45 cm (16–18 in) long, 20–25 cm (8–10 in) in diameter, greenish yellow. Peduncle short, cone appearing sessile. Sporophylls 5.5–6 cm (2.2–2.4 in) long. Sporophyll face 3.5–4.5 cm (1.4–1.8 in) high, 4.5–5.5 cm (1.8–2.2 in) wide, hardly protruding, somewhat flat and smooth, the facets indistinct, generally ranging from greenish yellow to pale cream, terminal facet with a warty ridge surrounding it, sometimes covered with brown tomentum, often sunken. Sarcotesta scarlet when ripe. Sclerotesta 26–30 mm (1–1.2 in) long, 18–20 mm (0.7–0.8 in) in diameter, light brown, smooth except for 11–14 longitudinal ridges that are prominent over the entire length. MALE CONES usually solitary, rarely two, cylindrical, 40–45 cm (16–18 in) long, 10–13 cm (4–5.1 in) in diameter, narrowing toward base and apex, generally apricot yellow to pale yellow. Peduncle 1–3 cm (0.4–1.2 in) long, 3–4 cm (1.2–1.6 in) in diameter, the cone generally appearing sessile. Sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 1.5 cm (0.6 in) high, 3.5–4 cm (1.4–1.6 in) wide, raised pyramidally, projecting 1–1.5 cm (0.4–0.6 in), sometimes with brown tomentum covering the terminal facet. Sporangia generally in a single patch covering the lower surface of the sporophyll but with a distinct notch at the outside edge, giving the impression of two patches. HABITAT: Steep rocky slopes and cliffs with sparse vegetation. Rainfall averages 625–750 mm (25–30 in) annually, generally falling in summer. The climate is hot in summer and cool in winter with frequent fog and mists. DISTRIBUTION: South Africa, Mpumalanga province, Pongola Valley and the upper catchment of the Pongola and Pivaan Rivers. Swaziland, north of Siteki (Stegi) in the area of Kangwane.

Encephalartos lebomboensis was first noticed as being different from its two closest relatives, *E. altensteinii* and *E. natalensis,* in the late 1920s. About 1930, Captain D. R.

Keith of Stegi (now Siteki), Swaziland, collected a number of cycads to plant along the entry road to his home. In 1935, thinking that the plants might represent a new species, Keith sent herbarium specimens of his cycads to both Kirstenbosch National Botanical Garden in South Africa and Ewanrigg garden in Southern Rhodesia (now Zimbabwe). Murray Ross Henderson, working at the Compton Herbarium at Kirstenbosch, examined a number of specimens collected in the Lebombo Mountains and also concluded that the cycad was undescribed. In the mid-1940s, Inez Clare Verdoorn and several other botanists studied the cycad in its habitat and agreed that it was new. At the time, they also noted that there appeared to be a difference in cone characteristics in some colonies along its distributional range. In 1949, Verdoorn described *E. lebomboensis* based on herbarium specimens she had collected, plus female and male cone specimens supplied from Keith's garden.

In the ensuing years, collectors noticed that there were two distinct forms of *Encephalartos lebomboensis.* One, referred to as the Piet Retief form, was characterized by its smaller size, smoother sporophylls, and closely packed leaflets, overlapping in a downward direction. Investigating the possibility that this might be an undescribed species, Piet Vorster studied the *E. lebomboensis* complex and its type and made an amazing discovery. The type specimen on which Verdoorn had based her description of *E. lebomboensis* is in fact the Piet Retief form. This meant that most of the cycads from the Lebombo Mountains that had been known as *E. lebomboensis* since 1949, including all the specimens rescued from the Josini Dam project, were in fact unnamed. Vorster described those plants in 1996 as *E. senticosus.*

Encephalartos lebomboensis differs from its near relatives by its smaller size, crowded leaflets that overlap in a downward direction, golden green rachis, and prominent spines on both the upper and lower margins of the leaflets. The spines, when viewed down the leaf length, fall into almost perfect alignment, giving the leaf a very distinctive appearance. Both female and male cones are greenish yellow, smooth, and have their flat terminal facets usually covered with a patch of light brown tomentum.

Reports indicate that the distribution of *E. lebomboensis,* which grows in the upper reaches of the Pongola and Pivaan Rivers with a disjunct population in Kangwane, does not overlap with those of *E. altensteinii, E. natalensis,* or its closest relative, *E. senticosus.* The distribution of *E. lebomboensis* does overlap in some areas with that of *E. villosus,* and apparent natural hybrids have been observed.

Encephalartos lebomboensis grows well in cultivation and produces handsome garden plants. Best suited to subtropical and temperate climates, plants grow equally well in both full sun and partial shade. This cycad is reasonably frost tolerant, but leaf damage can be expected during hard freezes. Production of cones is regular after plants are well established, adding to their interest and appearance. *Encephalartos lebomboensis* grows rapidly from seed, and a fair sized plant can be produced in about 5 years. This species is easy to grow and undemanding in its type of soil.

Encephalartos lebomboensis must be considered threatened. There are two small populations and both have suffered the inroads of poachers. Because *E. lebomboensis* is a handsome cycad, it will no doubt remain in demand as a garden plant.

Encephalartos lehmannii (Ecklon & Zeyher) Lehmann 1834

PLATES 302, 303

Zamia lehmanniana Ecklon & Zeyher 1833
Zamia pungens [Linnaeus fil. in] Aiton 1789, *Encephalartos pungens* (Aiton) Lehmann 1834
Encephalartos elongatus Lehmann in de Vriese 1838, *Zamia elongata* (Lehmann) Heynhold 1841
Encephalartos spinulosus Lehmann in de Vriese 1838, *Zamia spinulosa* (Lehmann) Heynhold 1841, *E. lehmannii* var. *spinulosus* (Lehmann) Miquel 1846
Encephalartos mauritianus Miquel 1842
Zamia occidentalis G. Loddiges 1843

Encephalartos lehmannii is named in honor of Johann Georg Christian Lehmann (1792–1860), director of the Botanical Gardens in Hamburg, Germany, and a researcher in cycads who published a number of papers dealing with them, including the description of the genus *Encephalartos.* **Stems** arborescent, erect, usually suckering from the base and forming two or more stems, to 1.5 m (4.9 ft) tall, and 25–50 cm (10–20 in) in diameter. **Leaves** numerous, spreading, 1–1.5 m (3–4.9 ft) long, 25 cm (10 in) wide, straight or with a tip curved slightly backward and downward, rarely curved or bowed, moderately keeled, the entire surface with a persistent silvery bloom. Petiole 25–30 cm (10–12 in) long, 1–1.3 cm (0.4–0.5 in) in diameter, unarmed, the swollen base with a conspicuous red-brown to yellow-brown collar. Basal leaflets not reduced to spines, median leaflets 12–18 cm (4.7–7.1 in) long, 17–19 mm (0.7 in) wide, attached horizontally to the rachis, spaced wider toward the base and closer in the upper half but rarely overlapping, margins flat and usually entire but occasionally with one or two small spines on the lower margin. **Female cones** solitary, erect, ovoid, 45–50 cm (18–20 in) long, about 24 cm (9.5 in) in diameter. Peduncle short, stout, hidden among the cataphylls, the cone appearing sessile. Median sporophylls about 6 cm (2.4 in) long. Sporophyll face 3.5 cm (1.4 in) high, 6 cm (2.4 in) wide, protruding about 2 cm (0.8 in), basically green but appearing blackish red because of a dense covering of short, dark tomentum on the sporophyll face, the facets smooth and distinct. Sarcotesta red when ripe. Sclerotesta somewhat ovoid, 21–30 mm (0.8–1.2 in) long, 16–18 mm (0.6–0.7 in) in diameter, light tan, with 7–10 low ridges of a lighter color. **Male cones** solitary, subcylindrical, erect, 37–49 cm (15–19 in) long, 10–11 cm (4–4.3 in) in diameter, narrowing toward apex and base, green, with a dense covering of short blackish red tomentum. Peduncle 3.5–5 cm (1.4–2 in) long, 3–3.5 cm (1.2–1.4 in) in diameter, yellow, glabrous. Sporophylls 4–4.5 cm (1.6–1.8 in) long. Sporophyll face 13–15 mm (0.5–0.6 in) high, 30–35 mm (1.2–1.4 in) wide, projecting 10–15 mm (0.4–0.6 in), the facets distinct. Sporangia in a single irregular patch. **Habitat:** Hot, dry sandstone hills and cliffs in areas of karoo scrub in association with *Euphorbia,* usually in full sun. Summer rainfall is usually no more than 350 mm (14 in) with periodic prolonged droughts. Winters are quite cold and frosts common. **Distribution:** South Africa, Eastern Cape province, Willowmore, Uitenhage, Steytlerville, Pearston, and Bedford districts, mainly in the catchment areas of the Groot and Sundays Rivers.

Encephalartos lehmannii was first described, as a *Zamia,* in 1833, making it one of the earliest known South African cycads. It was identified under several different names that were all reduced to synonymy under *E. lehmannii* by John Hutchinson and George Rattray (1933). In 1965 Robert Allen Dyer segregated *E. trispinosus* and *E. princeps* from what was known as the *E. lehmannii–E. horridus* complex. The basis for this separation was sound and should not present any further problems. Because the distributional areas of these four species are quite large, plants with atypical leaf and leaflet forms are common, sometimes confusing. As the main difference between the species is based on cone characteristics, it may sometimes be difficult to identify some of the variants to the level of species until cones are produced.

One of the more divergent forms of *Encephalartos lehmannii* is a population from near Kirkwood, Eastern Cape. The striking difference in these plants is that they have leaves that are curved or bowed and longer leaflets. I have also noticed that the seeds are much smaller and more round than in typical *E. lehmannii.* These plants, with their strongly and evenly arching leaves, are to me the most beautiful variant of the species.

The closest relatives of *Encephalartos lehmannii* are *E. horridus, E. princeps,* and *E. trispinosus.* The almost spine- and lobe-free leaflets of *E. lehmannii* readily distinguish it from *E. horridus* and *E. trispinosus.* More difficult to distinguish is *E. princeps,* which has leaflets crowded in the apical half of the leaf, strongly overlapping in the apical quarter. In *E. lehmannii,* the leaflets are not crowded, are inserted flat into the rachis, and do not overlap at the leaf apex.

Natural hybrids have been reported between *Encephalartos lehmannii* and *E. horridus,* but they are apparently rare. No information regarding these plants is available to me. There is a population of gray-leaved *E. longifolius* that may be the end product of hybridization that took place with *E. lehmannii* many years ago.

Encephalartos lehmannii is a very rewarding and trouble-free plant in cultivation. It is undemanding in its needs and able to withstand full sun in summer and frost in winter. Its pleasing shape and intense blue color have made it a popular garden and conservatory plant. In cultivation, it has a fairly rapid growth rate, and seedlings quickly attain a reasonable size. Around the home, both in the garden and as a container plant, it can be used in a variety of landscape applications.

Encephalartos lehmannii, until more recently, occurred in relatively large numbers within its area of distribution. This situation has changed rapidly. The reduction in numbers has taken place mainly as the result of the popularity of these plants in landscaping. Other factors pressuring the populations are domestic goats that eat the soft new leaves and damage the crown, and porcupines that eat into the bases of the stems during periods of drought, severely damaging or killing the plant. Added to all this is the low regeneration rate of *E. lehmannii,* mainly the result of its growing in areas heavily infested with a curculionid weevil. This weevil parasitizes the cones, destroying almost all developing seeds. *Encephalartos lehmannii,* like most South African cycads, is in dire need of protection. No preserves have been set aside for its protection, and its conservation status must be considered as severely threatened.

Encephalartos longifolius (Jacquin) Lehmann 1834

PAGE 1, PLATES 304, 305

Zamia longifolia Jacquin 1801

The epithet for *Encephalartos longifolius* is derived from *longi-,* Latin for long, and *folium,* leaf, referring to the relatively long leaves. **Stems** arborescent, erect, solitary or suckering from the base, 3–4.5 m (10–15 ft) long, 30–45 cm (12–18 in) in diameter. **Leaves** numerous, spreading, 1–2 m (3.3–6.6 ft) long, 18–23 cm (7.1–9.1 in) wide, moderately keeled, straight or with the apex curved backward and downward, sometimes curved or bowed, emergent leaves finely tomentose, glabrous with age. Petiole 10–35 cm (4–14 in) long, 1–1.4 cm (0.4–0.6 in) in diameter. Leaflets dark green or with a bluish bloom, overlapping in the upper half of the leaf, covered with a light but persistent fine tomentum, basal leaflets reduced in size but not to prickles, median leaflets 15–20 cm (6–8 in) long, 2–3 cm (0.8–1.2 in) wide, apex either blunt or with an apical spine, margins flat, usually entire or sometimes with one to three short teeth or bumps on the lower edge. **Female cones** one to three, erect, ovoid, 50–60 cm (20–24 in) long, 30–40 cm (12–16 in) in diameter, greenish brown with a light covering of reddish tomentum. Peduncle short, cone appearing sessile. Sporophylls 7.5–8 cm (3–3.2 in) long. Sporophyll face 4 cm (1.6 in) high, 5–6 cm (2–2.4 in) wide, projecting 2–2.5 cm (0.8–1 in), the surface coarsely wrinkled and pimpled. Sarcotesta red when ripe. Sclerotesta ovoid, 29–34 mm (1.1–1.3 in) long, 19–25 mm (0.8–1 in) in diameter, dark brown, smooth. **Male cones** one to three, erect, subcylindrical, 40–60 cm (16–24 in) long, 14–20 cm (5.5–8 in) in diameter, greenish brown, finely covered with reddish tomentum. Peduncle 3–5 cm (1.2–2 in) long, 4–4.5 cm (1.6–1.8 in) in diameter. Sporophylls 40–52 mm (1.6–2 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) high, 25–30 mm (1–1.2 in) wide, projecting about 20 mm (0.8 in) and ending in a truncate terminal facet about 8 mm (0.3 in) in diameter, its facets clearly defined. Sporangia in a single patch covering the underside of the sporophyll except for a narrow sterile margin. **Habitat:** A range of habitats from mountain slopes and ridges at elevations of about 1500 m (4900 ft) to flatter, exposed grassland in coastal valleys at about 200 m (650 ft), also in much drier areas such as Paardepoort in association with karoo scrub. Soil is sandstone based and invariably has an acidic pH. Rainfall ranges from 1250 mm (49 in) annually near the coast to as little as 300 mm (12 in) in the northern, more desertlike habitats. *Encephalartos longifolius* grows in the region between summer and winter rainfall areas so rain may occur throughout the year. **Distribution:** South Africa, Eastern Cape province, in the Humansdorp, Somerset East, and Uitenhage districts.

Encephalartos longifolius was first collected by the Swedish botanist Carl Peter Thunberg in 1772, making it one of the first South African cycads to be thus documented. Thunberg collected two species of cycads on this expedition, which he mistakenly considered juvenile and adult forms of the same species that he named *Zamia caffra* (= *E. caffer*) in 1775. In 1801, Nicolaus Joseph von Jacquin discovered Thunberg's mistake and named the larger one *Z. longifolia.* In 1834, Johann Georg Christian Lehmann transferred both species into his newly described genus *Encephalartos.*

The nearest relative of *Encephalartos longifolius* is *E. altensteinii,* from which it differs in a number of respects. *Encephalartos longifolius* has leaves curved backward and downward, or curved or bowed, rather than straight, and very dark green rather than light or yellowish green, leaflets overlapping rather than flat, and dull and finely hairy rather than smooth and glossy, stems dark blackish brown rather than light tan, and cones olive green with red-brown tomentum rather than golden yellow. In spite of the fact that *E. longifolius* is not fast growing, it is still a popular cycad in gardens. The rich, dark green color of its strongly curved or arching leaves coupled with its broad leaflets, held in a V formation in cross section, combine to produce a very handsome plant.

Encephalartos longifolius produces some of the largest female cones known in the genus, with some individual cones weighing as much as 30–40 kg (66–88 pounds). This species has hybridized naturally with *E. horridus,* the resultant plants showing intermediate leaf and cone characteristics (Plate 14). In the Kleinwinterberg near Paardepoort, a colony of *E. longifolius* occurs in which the plants look as if they could have sprung from a hybrid population produced with *E. lehmannii.* The plants in this colony are gray leaved, robust, and fast growing. *Encephalartos lehmannii* is found but a few miles away, and one can only surmise if at one time the two species may have overlapped at this locality. This colony of gray-leaved *E. longifolius* appears to be quite stable in its characteristics, which would seem to indicate that the two species have been isolated for many hundreds, if not thousands, of years.

Although scores of individuals of *Encephalartos longifolius* have been plundered from their habitat, the natural population is still quite secure because many of its colonies occur in remote areas or in protected nature preserves and government forest areas. In more recent years, *E. longifolius* has been cultivated from seed by nurserymen on a relatively large scale. Making these nursery-grown plants available to collectors has taken a great deal of pressure off the wild populations. A conservation status of vulnerable seems justified.

Encephalartos macrostrobilus S. Jones & Wynants 1997

The epithet for *Encephalartos macrostrobilus,* derived from *macros,* Greek for large, and *strobilus,* cone, referring to the large female cones, bears the local tribal name *ci-cia,* meaning "resembling the date palm," *Phoenix.* **Stems** arborescent, erect or decumbent with age, often suckering from the base, to 2.5 m (8.2 ft) long, 30–45 cm (12–18 in) in diameter. **Leaves** usually 35–60, spreading, erect, rigid, straight but sometimes curved backward and downward at the apex, dark green, 1.4–2.2 m (4.6–7.2 ft) long, 39–59 cm (15–23 in) wide. Petiole 12–15 cm (4.7–6 in) long, base strongly bulbous. Leaflets generally paired and opposite, inserted at about right angles to the rachis, stiff, glabrous, with 21 longitudinal veins that are not raised, basal leaflets abruptly reduced to one to three pairs of bifid spines, median leaflets 19–25 cm (7.5–10 in) long, 3.5 cm (1.4 in) wide, lanceolate, the leaflet apex bent toward the leaf apex, margins slightly revolute, the upper margin with six to eight teeth 2–6 mm (to 0.2 in) long and no farther than 6–8 cm (2.4–3.2 in) from the rachis, the lower margin with two to four teeth 2–5 mm (to 0.2 in) long and no farther than 3–8 cm (1.2–3.2 in) from the rachis. **Female cones** usually one to three, at first erect, angled or drooping at maturity, to 80 cm (32 in) long and 30 cm (12 in) in diameter, deep green at first, olive green at maturity, glabrous. Peduncle 12–14 cm (4.7–5.5 in) long. Sporophyll face about 33 mm (1.3 in) high and 50 mm (2 in) wide, rhombic, the exposed face smooth to minutely scalloped, the facets distinct. Sarcotesta yellow to deep orange-yellow to reddish yellow when ripe. Sclerotesta 32–36 mm (1.3–1.4 in) long, 19–25 mm (0.8–1 in) in diameter. **Male cones** usually 6–14, narrowly ovoid, erect, 18–20 cm (7.1–8 in) long, 4.5–5 cm (1.8–2 in) in diameter, deep green to olive green. Peduncle 8–9 cm (3.2–3.5 in) long. Sporophylls 20–28 mm (0.8–1.1 in) long. Sporophyll face smooth to minutely scalloped, the facets distinct and the exposed face about 13 mm (0.5 in) high and 25 mm (1 in) wide. Sporangia in a single patch covering the underside of the sporophyll. **Habitat:** Degraded savanna with the tree canopy 5–20 m (16–66 ft) high, usually along seasonal watercourses in rocky areas, in sandy soils, at elevations of 900–1400 m (3000–4600 ft). **Distribution:** Uganda, northwestern part of the country near the village of Mardiopei, in the area of the Madi people.

It is not clear just when the cycad that was to become *Encephalartos macrostrobilus* was first noted or by whom. Information from northern Uganda and southern Sudan has been sketchy since Georg August Schweinfurth's description of *E. septentrionalis* in 1871. I have not seen specimens of *E. macrostrobilus* so cannot comment with any authority on its relationships with the other cycads from the general area of its distribution. Even now there seems to be some confusion about the range and characteristics of *E. septentrionalis.* There appear to be at least three species from the general area of southern Sudan and northern Uganda. *Encephalartos septentrionalis* has been reported from four locations in this region, *E. macrostrobilus* from near the village of Mardiopei in northern Uganda, and an undescribed species from the Didinga Hills in southeastern Sudan, I have little doubt that it will be some time before the relationships of *Encephalartos* in this area have been clarified.

Encephalartos macrostrobilus differs from *E. septentrionalis* in its larger, erect stems as opposed to subterranean or short, decumbent ones, its thick crown of leaves as opposed to 12–24 untidy leaves, its larger female cone, about 80 cm (32 in) long as opposed to 27–36 cm (11–14 in), at maturity olive green with yellow to orange-yellow seeds as opposed to light brown with red seeds, and its very slender male cones.

To my knowledge there are no plants of *Encephalartos macrostrobilus* in cultivation except for a few seedlings, therefore no information is available about its cultivation requirements. One would expect it to conform to the conditions necessary for growing other tropical species such as *E. tegulaneus* or *E. whitelockii.*

The conservation status of *Encephalartos macrostrobilus* is not well documented as the few colonies that are known are small and scattered. The land is heavily used by the Madi people for grazing cattle and goats, and also for the production of timber and fuel, which has led to the deterioration of the tree cover. With the information available, *E. macrostrobilus* must be considered as endangered.

Encephalartos manikensis (Gilliland) Gilliland 1939

PLATES 306, 307

Encephalartos gratus var. *manikensis* Gilliland 1938

The epithet for *Encephalartos manikensis* refers to Manica district of Southern Rhodesia (now Zimbabwe), where this cycad was discovered. **Stems** solitary or suckering from the base to form clumps, to 1.5 m (4.9 ft) tall and 30 cm (12 in) in diameter. **Leaves** numerous, erect, ovate lanceolate to oblong, 1–1.9 m (3.3–6.2 ft) long, 24–30 cm (9.4–12 in) wide. Petiole subcylindrical, white woolly when emergent, glabrous when mature, 5–6.3 cm (2–2.5 in) long, 2–2.3 cm (0.8–0.9 in) in diameter. Leaflets in about 60 pairs, gradually reduced to prickles at the base, median leaflets 12–15 cm (4.7–6 in) long, 2–2.5 cm (0.8–1 in) wide, lanceolate ovate, pungent, margins entire or with one or two diverging spines on the upper or lower margin. Female cones one or two, rarely three or four, 30–45 cm (12–18 in) long, 20–25 cm (8–10 in) in diameter, light to dark green, glabrous. Peduncle 5–6 cm (2–2.4 in) long, 4.5 cm (1.8 in) in diameter. Median sporophylls rhomboid, about 4 cm (1.6 in) high and 5.5 cm (2.2 in) wide, the facets distinct and generally smooth, the inner margin of the lobes and upper margin of the sporophyll face papillose. Sarcotesta bright red when ripe. Sclerotesta ovoid, somewhat angled by compression, 2.5–3.5 cm (1–1.4 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, tan, smooth. Male cones one to four, erect, ovoid, 25–65 cm (10–26 in) long, 15–22.5 cm (6–9 in) in diameter, light green. Peduncle to 15 cm (6 in) long and 5 cm (2 in) in diameter, subtended by about eight triangular ovate, tomentose cataphylls, the cone appearing sessile. Median sporophylls 4–6 cm (1.6–2.4 in) long. Sporophyll face 25–33 mm (1–1.3 in) high, 35–58 mm (1.4–2.3 in) wide, the facets distinct and generally smooth. Sporangia in a single oval patch. Habitat: Grassy slopes under the protection of small trees at elevations of about 1400 m (4500 ft). *Encephalartos manikensis* may be the dominant plant in some areas. Distribution: Zimbabwe, Mount Gorongowe (type locality), and possibly several locations in Mozambique. The Mozambique populations will have to be investigated in more detail to make positive identification.

The discoverer and describer of *Encephalartos manikensis,* Hamish Boyd Gilliland, was a professor of botany at the Witwatersrand University in South Africa. He had heard rumors of a cycad near the eastern border of Southern Rhodesia (now Zimbabwe) in early 1934. It was not until July 1937 that he was able to verify its existence. At that time, in the early cycad exploration of the area, Gilliland was convinced that the plant in question was a form of *E. gratus,* a native of neighboring Malawi, and described it in 1938 as *E. gratus* var. *manikensis.* Gilliland realized after he had time to study specimens of *E. gratus* that there were significant differences between it and the plants from Manicaland, elevating the variety to the rank of species.

Encephalartos manikensis is a very decorative and fast-growing cycad. The most remarkable aspect of this species is the size of the male cones. They are almost as large as the females, and a positive determination must usually await the shedding of pollen. *Encephalartos manikensis* is not large growing and stems in excess of 1 m (3.3 ft) tall can be considered exceptional. Its rate of growth in the wild is much slower than in cultivation, probably the result of poor soil and the very rocky areas it inhabits. This cycad can be seen growing on the sheer cliffs of the granite dome of Mount Gorongowe, a very inhospitable area for both plants and people.

Encephalartos manikensis is hardy to several degrees of frost and will withstand a great deal of direct sun. Given a well-drained growing medium, well fertilized, it will attain coning size in about 10 years from seed. It is a moderate sized plant that will grow equally well in both sun and shade. This species is generally a trouble-free garden plant, best suited to subtropical and temperate climates.

Except for humans, the only enemy of consequence for *Encephalartos manikensis* is a large weevil whose larvae attack the apex of the stem. This weevil lays its eggs in the apex of the cycad, and the hatching larvae bore into the crown and so damage it that the apex is killed. The only subsequent growth that can be made is from offsets at the plant's base. I have seen some specimens die from the predation of these insects, but these are usually plants that are stressed for water or that have been transplanted. These same weevils have been introduced into various gardens in other countries through infected plants sent from Africa. Control is very difficult to attain as the larvae live within the stems for several months. Often, it is not known that a plant is infected until the day leaves drop. At that point, it is usually too late for treatment.

Natives who would take them to nearby towns to sell to gardeners have removed numerous plants from the habitat. This practice has all but stopped in more recent years as a result of enforcement of plant protection laws. *Encephalartos manikensis* was evidently common enough to have withstood these depredations for so many years. Though no longer common, *E. manikensis* is not rare but must be considered threatened.

Encephalartos marunguensis Devred 1959

PLATE 308

The epithet for *Encephalartos marunguensis* refers to the Marungu Plateau of the Democratic Republic of the Congo (Zaire), where this cycad was discovered. Stems solitary or rarely branched, subterranean to somewhat arborescent (?), to 40 cm (16 in) long, 12–16 cm (4.7–6.3 in) in diameter. Cataphylls linear lanceolate, 10 cm (4 in) long, 1–1.5 cm (0.4–0.6 in) wide. **Leaves** 10–22, curved slightly backward and downward, 60–85 cm (24–34 in) long, moderately keeled, covered with a beige tomentose to woolly covering when emergent, glabrous when mature. Petiole 1.3–2 cm (0.5–0.8 in) long with a swollen base. Leaflets in 50–85 pairs, linear lanceolate, glaucous green when fresh, basal leaflets reduced to prickles, median leaflets 10–11 cm (4–4.3 in) long, 12–13 mm (0.5 in) wide, margins flat, entire or rarely with a single spine. **Female cones** solitary, rarely two, ovoid cylindrical, 18–30 cm (7.1–12 in) long, 10–14 cm (4–5.5 in) in diameter, dark green or blue-green. Peduncle short, cone appearing sessile. Sporophylls 4.5–5 cm (1.8–2 in) long. Sporophyll face 3–3.5 cm (1.2–1.4 in) high, 5–5.5 cm (2–2.2 in) wide, the central facet distinct and relatively smooth, lateral facets indistinct and wrinkled. Sarcotesta yellow when ripe. Sclerotesta ovoid, 23–25 mm (0.9–1 in) long, 15–18 mm (0.6–0.7 in) in diameter, tan. **Male cones** one to three, ellipsoid to subcylindrical, 18–27 cm (7.1–11 in) long, 5.5–7.5 cm (2.2–3 in) in diameter, dark green. Peduncle 25–35 mm (1–1.4 in) long, 18–20 mm (0.7–0.8 in) in diameter, surrounded at the base by about 10 cataphylls 30–34 mm (1.2–1.3 in) long, 5 mm (0.2 in) wide, the lower side densely beige tomentose. Sporophyll face 15–18 mm (0.6–0.7 in) high, 20–26 mm (0.8–1 in) wide, all facets more or less smooth and distinct. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Savanna woodland and steppe shrubland at elevations of 1500–1690 m (4900–5500 ft). **Distribution:** Democratic Republic of the Congo (Zaire), Haut-Katanga district, Muhila Plateau.

Encephalartos marunguensis, though described in 1959, is still almost unknown in botanical gardens and private collections worldwide. Because of the paucity of specimens in the wild, the remoteness of the growing area, not to mention the political difficulties associated with travel in Zaire, this species has not often been seen by botanists. Even now, information is scant on its general characteristics. Data are confusing and at times contradictory, with some descriptions stating that the stem is always subterranean whereas others describe it as arborescent. All the specimens I have seen, all of which were cultivated, appear to be subterranean in growth.

Because of the scarcity of *Encephalartos marunguensis* in cultivation, not much is known about its horticultural requirements. It would seem that it would not be much different in its requirements from other similar cycads from dry tropical areas. The few plants of which I know in cultivation have seemed quite healthy, posed no horticultural problems, and have grown and coned normally.

The conservation status of *Encephalartos marunguensis* is insufficiently known. Until the completion of additional fieldwork to ascertain its range and remaining numbers, this interesting cycad must be considered endangered. It is hoped that some interested researcher or collector will collect seed for distribution to ensure the survival of this species.

Encephalartos middelburgensis Vorster, Robbertse & S. van der Westhuizen 1989

PLATES 309–311

Encephalartos eugene-maraisii subsp. *middelburgensis* Lavranos & D. L. Goode 1988

The epithet for *Encephalartos middelburgensis* refers to Middelburg, Mpumalanga province, South Africa, the town near where this cycad was discovered. **Stems** arborescent, erect, unbranched but suckering from the base to form clumps, erect to 6 m (20 ft) but over that height usually decumbent, 5–10 m (16–33 ft) long, 35–45 cm (14–18 in) in diameter. **Leaves** numerous, straight, upright, stiff, tapering toward the apex, 1.2–1.5 m (3.9–4.9 ft) long, 7.5–10 cm (3–4 in) wide, strongly keeled, with a persistent silvery bloom. Petiole 30–40 cm (12–16 in) long, 15–17 mm (0.6–0.7 in) in diameter, base swollen, rounded, densely tomentose. Leaflets in an acutely keeled formation, twisted at their attachment and overlapping in a downward direction, the upper surface of the leaflet facing the leaf apex, more or less equally acuminate, basal leaflets reduced to a few prickles, median leaflets leathery, rigid, 17.5–20 cm (7–8 in) long, 1.5 cm (0.6 in) wide, margins entire or occasionally with one spine on the lower margin. **Female cones** one to six, rarely as many as eight, cylindrical, 35–45 cm (14–18 in) long, 17–20 cm (6.7–8 in) in diameter, green, with fine brown tomentum more or less highlighting the terminal facet of each sporophyll, apex blunt. Peduncle short, cone appearing sessile. Sporophyll face hexagonal, 3.5–4.5 cm (1.4–1.8 in) high, 6–7.5 cm (2.4–3 in) wide, the surface appearing somewhat smooth but the lateral facets finely and unevenly wrinkled with ridges radiating from the terminal facet. Sarcotesta light brown to yellow when ripe. Sclerotesta slightly flattened, 31–35 mm (1.2–1.4 in) long, 19–25 mm (0.8–1 in) in diameter, light brown, with 11–15 smooth ridges or faint to almost invisible longitudinal grooves. Chalaza flat, 13–17 mm (0.5–0.7 in) in diameter. **Male cones** one to eight, erect, cylindrical to narrowly ovoid, 30–35 cm (12–14 in) long, 8.5–

12 cm (3.3–4.7 in) in diameter, not tapering toward the apex, green, with an overlay of dark brown tomentum. Peduncle 6–12 cm (2.4–4.7 in) long. Sporophyll face about 1.5 cm (0.6 in) high and 2.5 cm (1 in) wide, drawn out into a drooping liplike apex, green, with an overlay of dark brown tomentum at the terminal facet. Sporangia in a single patch covering the underside of the sporophyll except for a narrow sterile margin. **Habitat:** Dry rocky scrub on flats and in steep-sided canyons, in full sun or partial shade, at elevations of 1000–1400 m (3300–4600 ft). Rainfall averages 625–750 mm (25–30 in) annually, falling mainly in summer. Winters are cold, and frosts not uncommon. **Distribution:** South Africa, Mpumalanga and Gauteng provinces, in the catchment of the Olifants River near Middelburg.

Originally known as the Middelburg form of *Encephalartos eugene-maraisii, E. middelburgensis* was not recognized as distinct until 1988 and was described as a species in 1989. In 1998 it had been described as a subspecies of *E. eugene-maraisii. Encephalartos middelburgensis* is quite distinct from *E. eugene-maraisii* of the Waterberg, differing from *E. eugene-maraisii* in its green cones with dark brown terminal facets rather than maroon cones, its longer, gradually tapering leaves without the upturned apex, its much taller, more upright trunks, and its equally acuminate leaflets that overlap in a downward rather than upward direction. The habitats are separated by about 100 km (60 miles), and no integration of these species is known to take place.

No natural hybrids are known though in some areas *Encephalartos middelburgensis* may be found in close proximity to *E. lanatus.* The lack of hybridization between these two species leads us to believe that there are two pollinators involved, possibly host specific.

Encephalartos middelburgensis is a robust plant in cultivation and grows quite rapidly with proper care and fertilization. It grows best in full sun, which brings out its silver-gray leaf color. As with other dry-habitat cycads, it needs well-drained soil for good health. This species is reasonably cold tolerant, and specimens have withstood extended periods of freezing temperatures without apparent damage.

In 1983 the Transvaal Division of Nature Conservation conducted a census of what would become *Encephalartos middelburgensis* and found only about 420 individuals remaining in habitat. Almost half were part of a single colony, the rest in scattered stands of 2–32 individuals each. This study also disclosed that virtually no viable seed was being produced in the wild, and very few immature plants were seen. The lack of smaller plants could well have been the result of gathering by collectors as it is known that numerous specimens have been removed from the wild in more recent years. Because of the small number of remaining plants, the lack of viable seed production, and the scarcity of young plants in the wild, *E. middelburgensis* must be considered endangered.

Encephalartos msinganus Vorster 1996c

PLATES 312, 313

The epithet for *Encephalartos msinganus* refers to Msinga, KwaZulu-Natal province, South Africa, the town where this cycad was discovered. **Stems** arborescent, erect or sometimes leaning, often suckering from the base to form clumps, to 3 m (10 ft) long, 35 cm (14 in) in diameter, crown densely brown woolly, dry leaf bases persistent. **Leaves** erect, rigid, straight to somewhat arching, 1.1–1.5 m (3.6–4.9 ft) long, 32–34 cm (13 in) wide. Petiole unarmed, glabrous, 2–10 cm (0.8–4 in) long. Leaflets spaced 1.5–2.5 cm (0.6–1 in) apart, glossy dark green, sometimes overlapping in a downward direction, angled forward about 30°, opposing leaflets at an angle of about 90° to each other, producing a V-shaped cross section, basal leaflets gradually reduced in length toward the petiole, the lowest reduced to prickles, median leaflets lanceolate, 14–17 cm (5.5–7 in) long, 1.6–2 cm (0.6–0.8 in) wide, margin toothed or entire, the apex acute and pungent. **Female cones** usually one or two, erect, ovoid, about 42 cm (17 in) long and 22 cm (8.7 in) in diameter, greenish yellow to bright yellow when ripe, the color somewhat obscured by a covering of brown tomentum. Peduncle very short, cone appearing sessile. Sporophylls with poorly defined facets, the surface warty, more or less raised toward the central facet. Sporophyll face about 33 mm (1.3 in) high and 55 mm (2.2 in) wide. Sarcotesta bright red when ripe. Sclerotesta long to short ovoid, 25–35 mm (1–1.4 in) long, 16–19 mm (0.6–0.7 in) in diameter, the surface smooth except for 10–11 distinct to indistinct longitudinal ridges. **Male cones** usually two to four, narrowly ovoid, 30–40 cm (12–16 in) long, 11–12 cm (4.3–4.7 in) in diameter, pale yellow, glabrous. Peduncle to 7 cm (2.8 in) long but the cone appearing sessile. Median sporophylls rhombic, apex drawn out into a prominent drooping beak at the central facet. Sporophyll face 1–1.5 cm (0.4–0.6 in) high, 2–2.5 cm (0.8–1 in) wide, with poorly defined facets. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Generally, short grassland on steep north-facing slopes, often among boulders and in shrub clumps, less commonly on sandstone cliff faces, usually in full sun, at elevations of 900–1200 m (3000–3900 ft). **Distribution:** South Africa, northern KwaZulu-Natal province, known only from the vicinity of Msinga near Tugela Ferry.

Before its description in 1996, *Encephalartos msinganus* was known as the Msinga form of *E. natalensis.* As with most cycads that are known informally as forms or varieties, it was not in demand by botanical gardens or private collectors, and for this reason the species is generally poorly represented in collections. *Encephalartos msinganus* is a distinctive species as well as a rare one, and this will no doubt cause an increased demand for it by collectors and botanical gardens alike.

Cone morphology suggests that *Encephalartos msinganus* bears close relationships to other species from the same general area of distribution, including *E. aemulans, E. altensteinii, E. lebomboensis, E. natalensis,* and *E. senticosus.* The glossy, dark green, somewhat arching leaves, the hard and pungent median leaflets, usually but not always with teeth along both margins, the reduction of the basal leaflets to spines, and the short petiole indicate a close relationship to *E. aemulans, E. lebomboensis,* and *E. senticosus.* There are also similarities between the female and male cones of these species and *E. msinganus. Encephalartos msinganus* can best be distinguished by its narrow leaflets and the warty surface of the megasporophylls.

In cultivation, *Encephalartos msinganus* is easy to maintain in good health and shows good resistance to frost and short periods of freezing weather. Its growth rate is moderate to rapid, depending on the growing conditions provided. Usually, it maintains numerous dark green, lustrous leaves in a somewhat erect crown. *Encephalartos msinganus* makes a fine addition to any landscape or collection. My experience with this species has been a positive one, and it has grown equally well in either full sun or shade. During the years I have had *E. msinganus* in cultivation, it has had no insect problems.

When the group of plants destined to become *Encephalartos msinganus* was discovered in the 1980s, the colony consisted of several hundred widely scattered individuals. Since that time, the activities of collectors and plant dealers have almost eradicated this species from its habitat. It is now considered endangered, on the brink of extinction.

Encephalartos munchii R. A. Dyer & I. C. Verdoorn 1969

PLATES 314, 315

Encephalartos munchii is named in honor of Raymond C. Munch (1901–1985), a collector and student of the *E. manikensis* complex in Zimbabwe and Mozambique. **Stems** arborescent, erect, stout, solitary in smaller specimens but larger plants suckering from the base to form clumps, to about 1 m (3.3 ft) tall and 30 cm (12 in) in diameter, covered by a series of leaf bases and cataphylls. Cataphylls narrowly ovate, acuminate, gray to white woolly on the outer surface, 12–13 cm (4.7–5.1 in) long, 2.5–3 cm (1–1.2 in) wide. **Leaves** numerous, narrowly oblong, slightly narrowed at the apex and gradually narrowed toward the base, 1–1.3 m (3.3–4.3 ft) long, 22–24 cm (8.7–9.4 in) wide, moderately keeled. Petiole somewhat slender, woolly at the base, 15–20 cm (6–8 in) long, 2 cm (0.8 in) in diameter. Rachis straight, at first suberect, then gradually spreading with age. Leaflets dull glaucous green, somewhat thin, turning yellowish to yellowish brown with age, in the upper half of the leaf crowded, overlapping, and directed toward the leaf apex, in the lower half inserted about 1 cm (0.4 in) apart, basal leaflets reduced to prickles, median leaflets linear oblong, somewhat equal-sided toward the base, 15–23 cm (6–9.1 in) long, 11–17 mm (0.4–0.7 in) wide, margins with numerous spines generally in the lower half of the leaflet, some prickles more than 5 mm (0.2 in) long, the pungent apex a continuation of the upper margin, the lower margin curved upward toward the apex. **Female cones** generally solitary, rarely as many as four or more, erect, subcylindrical or barrel shaped, 30–50 cm (12–20 in) long, 16–20 cm (6.3–8 in) in diameter, narrowing toward the blunt apex, jade green to glaucous green. Peduncle about 10 cm (4 in) long and 8 cm (3.2 in) in diameter, subtended by narrow woolly cataphylls about 15 cm (6 in) long, the cone appearing sessile. Median sporophylls about 6 cm (2.4 in) long. Sporophyll face 3.5–4 cm (1.4–1.6 in) high, 4.5–5 cm (1.8–2 in) wide, the terminal facet 1.5 cm (0.6 in) high and wide, with a prominent margin from which well-defined ridges radiate. Sarcotesta scarlet when ripe. Sclerotesta long ovoid, 27–35 mm (1.1–1.4 in) long, 20–24 mm (0.8–0.9 in) in diameter, light tan, more or less smooth. **Male cones** one to six, erect, subcylindrical, 40–65 cm (16–26 in) long, 7–9 cm (2.8–3.5 in) in diameter, narrowing gradually toward apex and base, jade green. Peduncle 16–20 cm (6.3–8 in) long, 37–50 mm (1.5–2 in) in diameter, smooth. Apical sporophylls spreading horizontally or slightly upward, those below becoming slightly deflexed, median sporophylls oblong cuneate, 3.5–4 cm (1.4–1.6 in) long. Sporophyll face 15–17 mm (0.6–0.7 in) high, 25–30 mm (1–1.2 in) wide, glabrous, the individual facets distinct. Sporangia in a single patch, extending almost to the lateral margins of the lower sporophyll surface. **Habitat:** Dry granite mountaintop and cliffs in full sun to semishade. Rain generally falls in summer. Temperatures are hot in summer, cool in winter. **Distribution:** Mozambique, known only from Mount Zembe, a giant granite outcrop about 12 km (7.4 miles) south of Chimoio (Vila Pery) in the catchment area of the Revuè River.

Encephalartos munchii was described in 1969 when Robert Allen Dyer and Inez Clare Verdoorn separated it from the *E. manikensis* complex. Specimens and data from the garden of Raymond C. Munch made possible the descriptions of *E. munchii, E. chimanimaniensis, E. concinnus,* and *E. pterogonus. Encephalartos munchii* as well as the other three species were based primarily on differences in the male cones. Without male cone material, the identification of these species can be quite difficult except in the case of *E. munchii,* which has very distinctive leaves. *Encephalartos munchii* is, in my opinion, the most different in its gray, spiny foliage as opposed to the green, not so spiny leaves of the other species. *Encephalartos munchii* is the most beautiful of the cycads included in the so-called *E. manikensis* complex. The long, glaucous leaves, with their exceptionally spiny leaflets, set it apart from the basically green and less spiny foliage of the other species in the complex. *Encephalartos munchii* is quite different in cone and leaf characteristics from the other cycad colonies of Mozambique and adjacent Zimbabwe. From its outward appearance, one could surmise that *E. munchii* is most closely related to *E. cupidus* of South Africa. In my opinion, the similarity is only a case of parallel evolution. When taken point by point, the only true similarities are the glaucous leaf color and the spiny margins of the leaflets.

Encephalartos munchii presents no major problems in cultivation if given well-drained soil. It does well in full sun, where it will develop a fine crown of spiny gray-green leaves. Low humidity is preferred, but I have seen a number of plants doing well in humid areas such as southern Florida. *Encephalartos munchii* is a fast-growing cycad and responds well to regular applications of fertilizer. High summer temperatures are beneficial, but this species is not tolerant of frost, so protection should be provided in areas exposed to temperatures below freezing. In my experience, *E. munchii* will withstand 1–2°C (34–36°F) of frost for brief periods without apparent foliar damage.

Encephalartos munchii is uncommon in cultivation, and propagation material in the form of seeds and offsets is not often available. In the southern California climate, this cycad tends to cone infrequently. I am happy to report that two collectors in southern California were successful in pollinating their female plants, thereby increasing the overall numbers of this species by several hundred. Individuals having female specimens in their collections should make every effort to produce viable seed, thus ensuring the continued existence of this beautiful species.

Encephalartos munchii is considered extremely endangered. The only known colony is restricted to Mount Zembe, Mozambique, and was discovered about 1960. In the 1970s, many specimens were removed from this colony to be placed in cultivation. At last report, the colony had been reduced to fewer than 100 plants. Since that time, the political situation in Mozambique has been such that no one has been able to investigate the status of this plant in the wild. In any case, the species must be considered extremely endangered. We can only hope that the government of Mozambique will take steps to protect not only *E. munchii* but also the other species of *Encephalartos* that occur within its boundaries.

Encephalartos natalensis R. A. Dyer & I. C. Verdoorn 1951

PLATES 10, 316, 317

The epithet for *Encephalartos natalensis* refers to the old Natal province, now KwaZulu-Natal, South Africa, in which this cycad was discovered. **Stems** arborescent, erect, usually unbranched but suckering freely from the base, commonly 3–4 m (10–13 ft) tall but very old specimens sometimes reaching a height of 6.5 m (21 ft), 30–40 cm (12–16 in) in diameter, commonly showing light brown wool in the crown. **Leaves** numerous, shining dark green, 1.3–3.2 m (4.2–10.5 ft) long, 32–46 cm (13–18 in) wide, nearly straight or sometimes curved slightly backward and downward and somewhat twisted at the apex, in cross section forming a broad V at the base and an acute V toward the apex. Petiole 10–20 cm (4–8 in) long, 1.6–2 cm (0.6–0.8 in) in diameter, basal leaflets gradually reduced toward the base and ending in several prickles just above the petiole, median leaflets 16–23 cm (6.3–9.1 in) long, 2.5–4.5 cm (1–1.8 in) broad, dark glossy green, margins on leaflets in younger plants with one to five sharp prickles on one or both sides, in mature plants the margins usually entire, even the terminal prickle lacking. **Female cones** one to five, ovoid, 50–60 cm (20–24 in) long, 25–30 cm (10–12 in) in diameter, golden yellow, at first quite woolly but almost glabrous with age. Peduncle short, cone appearing sessile. Sporophyll face 3–

4 cm (1.2–1.6 in) high, 4.5–5 cm (1.8–2 in) wide, projecting about 2 cm (0.8 in), deeply wrinkled, pimpled, with a prominent, rough, brown tomentose terminal facet. Sarcotesta scarlet to orange-red when ripe. Sclerotesta 30–34 mm (1.2–1.3 in) long, 17–18 mm (0.7 in) in diameter, the surface generally smooth except for 11–13 prominent longitudinal ridges. **Male cones** one to five, spindle shaped, 45–55 cm (18–22 in) long, 10–12 cm (4–4.7 in) in diameter, paler yellow than the female cones, with a thin woolly covering when young that is soon lost. Peduncle 2–4 cm (0.8–1.6 in) long, 2.5 cm (1 in) in diameter. Sporophylls 34–37 mm (1.3–1.5 in) long. Sporophyll face 10–12 mm (0.4–0.5 in) high, 20–22 mm (0.8–0.9 in) wide, projecting 15–20 mm (0.6–0.8 in), yellow, with a light covering of brown scales. Sporangia in a single patch with a narrow sterile margin surrounding it and a central sterile notch at the front and back. **Habitat:** Inland areas well away from coastal vegetation, normally on cliffs or steep hillsides, usually in full sun. **Distribution:** South Africa, from the Eastern Cape province to the border with southern KwaZulu-Natal province, northward to the upper catchment area of the Umfolozi River.

Prior to its description, *Encephalartos natalensis* was classified as *E. altensteinii.* When John Hutchinson and George Rattray (1933) did the cycads for *Flora Capensis,* they included all the arborescent *Encephalartos* in Natal, except *E. woodii,* in *E. altensteinii.* They admitted, however, that they had never seen specimens from Natal. Murray Ross Henderson (1945) maintained the Natal plants as *E. altensteinii,* also recognizing *E. woodii.* Here again, Henderson admitted that he had never seen specimens of the Natal plants. With this background it is not surprising that *E. natalensis* was not recognized as a distinct species until 1951, when it was described by Robert Allen Dyer and Inez Clare Verdoorn.

When one takes into account that *Encephalartos natalensis* shares several morphological features with *E. altensteinii,* such as large stems, yellow cones, and long, green leaves, it is not too surprising that confusion existed. The following differences can be used to distinguish the two species. In *E. natalensis* the lower leaflets are reduced to spines, leaves are dark green rather than yellowish green, leaflets are broader, stiffer, not glossy green, and the plants sucker freely. The distribution is also useful as *E. natalensis* grows inland rather than along the coast, and the two species do not overlap at any place in their respective ranges.

Encephalartos natalensis is most closely related to *E. altensteinii* and, somewhat more distantly, to *E. lebomboensis* and *E. woodii.* There are several forms of *E. natalensis,* the four primary ones designated by the towns closest to their habitats: Hardina, High Flats, Kranskop, and Vryheid. I have not had the opportunity to study mature specimens of any of these forms, but the seedling plants I have seen are distinct enough to be easily separated from each other. These various forms are being investigated, and conclusions regarding their taxonomic status should be forthcoming.

I am not aware of any natural hybrids involving *Encephalartos natalensis,* but Cynthia Giddy made a cross with *E. woodii.* The hybrid plants varied considerably, some showing definite *E. woodii* characteristics, others looking more like *E. natalensis.* Some of these hybrids developed into handsome specimens of unusually rapid growth. It has been suggested that hybrids with *E. villosus* may occur in the Krantzkloof area of KwaZulu-Natal where these two species come into direct contact. A garden hybrid between *E. natalensis* and *E. ferox* is also known.

Encephalartos natalensis is well represented in collections, both public and private, probably because it is relatively common and also because of its ease in horticulture and rapid growth. It is one of the undemanding cycads, seeming to adapt to most soil conditions in temperate and tropical areas. Seed is usually viable, and germination rates are generally high. Variegated specimens exist (Plate 10).

If we accept all the forms of *Encephalartos natalensis* as the same species, it is definitely not a threatened plant. On the other hand, if some of its forms are found to be distinct and removed from *E. natalensis,* that could make a great deal of difference in the conservation status of each. At present, *E. natalensis* is one of the most common South African species of the genus. Large colonies occur on protected land and in remote areas, and regeneration in the wild is abundant. In more recent years, many thousands of seedlings have been produced for the nursery trade, and if this continues it will eventually reduce the pressure on wild populations. Under the current taxonomic treatment, *E. natalensis* may be considered as not threatened.

Encephalartos ngoyanus I. C. Verdoorn 1949a

PLATES 318, 319

The epithet for *Encephalartos ngoyanus* refers to the Ngoye Forest, the type locality for this species in Zululand, northeastern KwaZulu-Natal province, South Africa. **Stems** subterranean, rarely branched due to injury, the tuberous contractile roots pulling the stem into the ground so that usually only the dome-shaped crown visible, mature excavated stems 30–40 cm (12–16 in) long, 15–20 cm (6–8 in) in diameter. **Leaves** 3–10 in a whorl, dark green, 0.6–1.2 m (2–3.9 ft) long, 14–16 cm (5.5–6.3 in) wide, slightly keeled. Petiole slender, 10–30 cm (4–12 in) long, 6–8 mm (0.2–0.3 in) in diameter just above the base, covered with long, silky, off-white tomentum that is especially dense at the base. Leaflets abruptly reduced in size toward the leaf apex, veins apparent on lower surface, base unequally narrowed to 3–4 mm at the attachment, basal leaflets gradually reduced, ending in very small leaflets, not prickles, median leaflets in a wide V formation on the rachis or sometimes flat, not crowded, linear lanceolate, 7–12 cm (2.8–4.7 in) long, 9–15 mm (0.4–0.6 in) broad, margins with one to three teeth on the lower margin or sometimes entire in older plants. **Female cones** solitary, obovoid, 20–25 cm (8–10 in) long, 12–15 cm (4.7–6 in) in diameter, yellow at maturity in the sun, green if in shade, glabrous. Peduncle short, cone appearing sessile. Sporophyll face about 3 cm (1.2 in) high and 4.5 cm (1.8 in) wide, flattened and overlapping the one below, lower margin generally relatively smooth but in some localities fringed. Sarcotesta scarlet when ripe. Sclerotesta ovoid, 21–28 mm (0.8–1.1 in) long, 17–19 mm (0.7 in) in diameter, dark brown, with 10–14 lighter colored longitudinal ridges. Chalaza 8–10 mm (0.3–0.4 in) long, 6–8 mm (0.2–0.3 in) wide. **Male cones** solitary, subcylindrical, 20–25 cm (8–10 in) long, 4.5–6 cm (1.8–2.4 in) in diameter, narrowed toward the apex, yellow at maturity in the sun or green in shade. Peduncle about 2 cm (0.8 in) long, the cone usually appearing sessile. Median sporophylls smooth, projected into a beak about 7–8 mm (0.3 in) long. Sporophyll face rhomboid, about 14 mm (0.6 in) high and 22 mm (0.9 in) wide. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Generally, grassland and forest margins, frequently among boulders where the cycads may be wedged into cracks. Rainfall averages 750–1000 mm (30–39 in) annually, falling in summer. **Distribution:** South Africa, KwaZulu-Natal province, from the Ngoye Forest in the south, in Ingwavuma, Mtunzini, Ngoye, and Ubombo districts, northward to Mkuze into northeastern KwaZulu-Natal at Pongola Poort. Swaziland, southern border area near Pongola Poort.

Before Inez Clare Verdoorn named *Encephalartos ngoyanus* in 1949 in *Flowering Plants of Africa,* it was often referred to as *E. brachyphyllus,* a name generally accepted as a synonym of *E. caffer.* There were two publications on South African *Encephalartos* prior to the description of *E. ngoyanus,* by John Hutchinson and George Rattray (1933), who treated the cycad as *E. caffer,* and by Murray Ross Henderson (1945), who felt it was an undescribed species, which proved correct.

Encephalartos ngoyanus has only one close relative, *E. caffer* of the Eastern Cape. The habitats of these two species are separated by approximately 500 km (300 miles) and no intermediates are known. The two species are similar in several respects such as habitat preference, short leaves, small subterranean stems, tuberous contractile roots, and yellow cones at maturity. On close examination, however, one can easily identify them. In *E. caffer* the leaflets are crowded, light green, overlapping, have entire margins and persistent tomentum. In *E. ngoyanus* the leaflets are well spaced, glossy dark green, not overlapping, sometimes have one to three teeth on the lower margins, and have no persistent tomentum. The sporophylls of *E. caffer* have both lateral and terminal facets and do not overlap the lower sporophylls whereas those of *E. ngoyanus* are flat and smooth, without distinct facets, and overlap the scales below. The only other species closely related to *E. ngoyanus* is *E. cerinus.* It can be distinguished from *E. ngoyanus* by its longer, stiffer leaves with a glaucous waxy coating, and orange cones also with a waxy coating.

Encephalartos ngoyanus grows well in cultivation if given well-drained soil and plenty of sun. It is relatively frost tolerant and has not displayed leaf damage at temperatures of −4°C (25°F). The small stature of this species makes it ideal for use as a pot plant or in small rockery areas. It is somewhat slow growing but continues to develop at a reasonable rate if fed often during the growing season. This cycad sometimes becomes deciduous before new leaves or cones are produced.

Encephalartos ngoyanus is a relatively rare plant, not often found in collections. In more recent years a substantial number of plants have been removed from habitat, thereby reducing natural regeneration. A few collectors have been successful in producing viable seed in their gardens, and in this way hundreds of additional plants are being cultivated. If this trend continues, *E. ngoyanus* will be in a much stronger position to survive. *Encephalartos ngoyanus* must be considered very threatened and should be given every protection possible.

Encephalartos nubimontanus P. J. H. Hurter 1995

PLATES 320, 321

Encephalartos venetus Vorster 1996e

The epithet for *Encephalartos nubimontanus* is derived from *nubilus,* Latin for gray-blue, the leaf color, and *montanus,* growing on mountains, referring to this cycad's habitat in the Wolkberg Mountains, Northern province, South Africa. **Stems** arborescent, erect or decumbent, suckering from the base to form clumps, to 2.5 m (8.2 ft) long, 35–40 cm (14–16 in) in diameter, crown slightly tomentose, leaf bases persistent. Cataphylls velvety white, becoming almost glabrous with age. **Leaves** numerous in a dense crown, curved backward and downward apically, rigid, glaucous, 1.1–2 m (3.6–6.6 ft) long. Petiole somewhat triangular, to 23 cm (9 in) long, the bulbous base with a reddish brown collar at maturity and lightly tomentose. Rachis glabrous, round in cross section, becoming somewhat yellow with age. Leaflets sparsely toothed or entire, angled forward about 45°, opposing leaflets at an angle of about 70° to each other, producing a V-shaped cross section, veins not raised below, margins slightly thickened, curved backward and downward when young like a shepherd's crook, median leaflets 18–25 cm (7.1–10 in) long, 1.5–2.5 cm (0.6–1 in) wide, narrowly elliptical, gradually acuminate toward the apical spine, which is somewhat turned toward the leaf apex. **Female cones** usually one to three, ovoid, 36–40 cm (14–16 in) long, 18–20 cm (7.1–8 in) in diameter, light green. Peduncle 15–31 cm (6–12 in) long. Median sporophylls rhombic, 5–6 cm (2–2.4 in) long. Sporophyll face 30–36 mm (1.2–1.4 in) high, 40–60 mm (1.6–2.4 in) wide, the terminal facet smooth, slightly concave, 3–5 mm (to 0.2 in) deep. Sarcotesta orange-red when ripe. Sclerotesta ellipsoid, rounded, 35–38 mm (1.4–1.5 in) long, 23–30 mm (0.9–1.2 in) in diameter, smooth. **Male cones** usually one to five per crown, subconical, 25–40 cm (10–16 in) long, 5–9 cm (2–3.5 in) in diameter. Peduncle 3–4.5 cm (1.2–1.8 in) long. Median sporophylls 2–3 cm (0.8–1.2 in) long, slightly descending. Sporophyll face 5–10 mm (0.2–0.4 in) high, 11–24 mm (0.4–0.9 in) wide, with two trapezoidal lateral facets, no median facet but a well-defined humplike, arrow-shaped ridge, the terminal facet a drooping liplike structure, often minutely scalloped. Sporangia in a single irregular patch covering most of the underside of the sporophyll. **Habitat:** Scattered plants in mixed deciduous woodland, especially on cliff faces, usually at an elevation of about 1000 m (3300 ft). **Distribution:** South Africa, a single small area of Northern province.

Encephalartos nubimontanus was for some time referred to as *E. venetus* but that name is a synonym and plant labels with it should be changed. Other names that have been applied to this species are *E. "venetus robusta,"* giant *cupidus,* and fifth *eugene-maraisii.* The plants display several leaf forms but all are said to have identical cones. I am not entirely convinced that there is only a single species involved in the *E. nubimontanus* complex.

The taxonomic treatment of *Encephalartos nubimontanus* has been made almost impossible because most of the plants in the wild have been poached to sell to collectors. Some colonies have been completely eradicated, leaving only garden plants available for study, most of which have no locality data. Even those collectors who knew where the plants had been collected would not disclose the information for fear of being prosecuted for possessing illegal plants, since none of the plants had ever been collected legally. The few plants that remain in habitat are at risk from poachers.

The specimens of *Encephalartos nubimontanus* that I have seen in cultivation were growing robustly and are very handsome. There seemed to be no problems with their cultivation, and coning was reasonably frequent once the plants were reestablished. A considerable amount of seed has been produced on garden plants, and this is always in demand and sells at high prices.

The conservation status of *Encephalartos nubimontanus* is not at all good. The most beautiful form, giant *cupidus,* has been completely eradicated in the wild. The other forms are on the brink of extinction. The only positive comment that can be made about the continued existence of *E. nubimontanus* is that there exists a small breeding colony in the Lowveld National Botanical Garden, Nelspruit, South Africa. If there is success in artificially producing viable seed, as there has been in private collections, it may well be the salvation of this extremely endangered cycad.

Encephalartos paucidentatus Stapf & Burtt Davy 1926

PLATES 322, 323

The epithet for *Encephalartos paucidentatus* is derived from *pauci-,* Latin for few, and *dentatus,* toothed, referring to the margins of the leaflets. **Stems** erect, unbranched or rarely branched above ground as a result of injury, sometimes suckering from the base, to 6 m (20 ft) long, 40–70 cm (16–28 in) in diameter, crown densely brown woolly. **Leaves** straight or slightly upcurved at the apex, 1.5–2.5 m (4.9–8.2 ft) long, 30–50 cm (12–20 in) wide. Petiole round, 20–30 cm (8–12 in) long. Rachis markedly yellowish, densely pubescent when emergent but glabrous with age. Basal leaflets reduced to lobes and then prickles, median leaflets usually falcate but sometimes straight with as many as 30 conspicuous raised longitudinal veins on the lower surface, gradually acuminate toward the apex, 15–25 cm (6–10 in) long, 2–3.5 cm (0.8–1.4 in) wide, dark glossy green above, dull yellowish green below, deflexed from the rachis, margins with one or more teeth. **Female cones** one to three, ovoid, 30–50 cm (12–20 in) long, 20–25 cm (8–10 in) in diameter, golden yellow, at first woolly and later more or less glabrous. Peduncle about 3 cm (1.2 in) long, stout, hidden among the cataphylls, the cone appearing sessile. Median sporophylls 2.5–3 cm (1–1.2 in) long. Sporophyll face 25–28 mm (1–1.1 in) high, 40–45 mm (1.6–1.8 in) wide, deeply wrinkled and drawn out into a beak, curved downward and projecting 15–20 mm (0.6–0.8 in). Sarcotesta red when ripe. Sclerotesta long ovoid, 35–40 mm (1.4–1.6 in) long, 19–22 mm (0.8–0.9 in) in diameter, dark tan, the surface covered with a mosaic of irregular shallow grooves, with 10–11 indistinct longitudinal grooves. Chalaza 8–12 mm (0.3–0.5 in) long, 8–9 mm (0.3–0.4 in) wide. **Male cones** one to five, spindle shaped, 40–60 cm (16–24 in) long, 12–15 cm (4.7–6 in) in diameter, golden brown, at first very woolly, gradually shedding the wool as they mature. Peduncle 10–12 cm (4–4.7 in) long, 2.5–3 cm (1–1.2 in) in diameter. Sporophylls 4–5.5 cm (1.6–2.2 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) high, 25 mm (1 in) wide, with a beak, curved downward and projecting 15–20 mm (0.6–0.8 in), the terminal facet with a toothed or scalloped lower margin. Sporangia in a single patch. **Habitat:** Mountain forests on steep, often rocky slopes, at elevations up to 1800 m (5900 ft). Rainfall is 1250–1500 mm (49–59 in) annually, falling mainly in summer. **Distribution:** South Africa, Mpumalanga province, Barberton district. Swaziland, Piggs Peak district.

The early history of *Encephalartos paucidentatus* is somewhat cloaked in mystery. The type specimen was thought to have been collected in 1908 on the Limpopo River in the Soutpansberg district of South Africa by Charles Legat, who was conservator of forests in the Transvaal province. Later expeditions were unable to locate the species in this area, and Robert Allen Dyer, after considerable research, concluded that the type specimen had been mislabeled. The only plants that have ever been found all occur in a small area in the Barberton district of Mpumalanga province and adjoining Swaziland.

The species most closely related to *Encephalartos paucidentatus* are *E. heenanii* and *E. transvenosus.* The distribution areas of *E. paucidentatus* and *E. transvenosus* do not overlap, but *E. heenanii* has been observed at one location to be within 1 km (0.6 mile) of *E. paucidentatus.* It has been reported that at least one plant was found that may be a hybrid between *E. paucidentatus* and *E. heenanii.* Given their close proximity, it is reasonable to believe that such a cross is possible.

Encephalartos paucidentatus is one of the most handsome species of the genus. Its relative rarity makes it a somewhat difficult species to obtain, and it is not common in collections. In more recent years, seed has become available on a fairly regular basis and the numbers in cultivation have increased dramatically. *Encephalartos paucidentatus* is relatively easy in cultivation and given the proper conditions grows rapidly. Its graceful leaves, with their falcate, deflexed leaflets, make this cycad a welcome addition to any garden. *Encephalartos paucidentatus* seems relatively cold tolerant in southern California and Florida, having withstood temperatures as low as −5°C (23°F) without leaf burn or any other apparent damage.

The Department of Nature Conservation of the Transvaal (now Mpumalanga) and the citizens of Barberton established the Ida Doyer Nature Reserve, where numerous specimens of *Encephalartos paucidentatus* grow and where it can be protected. This cycad is still in need of the most stringent protection because of the small number remaining in the wild. In past years, many specimens were removed from Swaziland, depleting the population and reducing seed production. The range of *E. paucidentatus* is limited to a relatively small area, and even within this area it cannot be considered common. *Encephalartos paucidentatus* must be considered endangered.

Encephalartos poggei Ascherson 1878

PLATE 324

Encephalartos lemarinelianus De Wildeman & Durand 1900

Encephalartos poggei, named in honor of Paul Pogge (d. 1884?), German plant explorer and collector who discovered this cycad in 1876 while traveling in the Belgian Congo, now the Democratic Republic of the Congo (Zaire), is called *tchiondo* by the Bena Kaniokas tribe, *biondo* by the Baluba tribe, *lulondo* and *kalala kabo* by the Bena-Luluas tribe, and *katende* by the Kabwe tribe. **Stems** short globular or erect cylindrical, rarely branched, to 2 m (6.6 ft) tall, 20–30 cm (8–12 in) in diameter, alternating cataphylls and persistent leaf bases covered with shaggy gray tomentum. **Leaves** as many as 12, erect, linear oblanceolate, tapering abruptly toward the base, 0.7–1.5 m (2.3–4.9 ft) long, 14–27 cm (5.5–11 in) wide, flat, curved backward and downward toward the apex. Petiole 7–20 cm (2.8–8 in) long, it and its swollen base covered with shaggy gray tomentum. Leaflets in 18–60 pairs, leathery, rigid, glaucous, lanceolate, with a pungent apex, median leaflets linear lanceolate, straight or falcate, 8–15 cm (3.2–6 in) long, 7–13 mm (0.3–0.5 in) wide, base narrowing abruptly above the attachment, which is 7–10 mm (0.3–0.4 in) wide, margins slightly revolute, entire, or sometimes with one to four spines on both sides near the base. Female cones usually solitary but sometimes as many as three, ovoid oblong, 17–23 cm (6.7–9.1 in) long, 9–12 cm (3.5–4.7 in) in diameter, green, then yellow when mature, apex slightly tapering, base truncate or rounded. Peduncle 2–5 cm (0.8–2 in) long and the cone usually appearing sessile. Sporophyll face 20–27 mm (0.8–1.1 in) high, 40–50 mm (1.6–2 in) wide, the facets poorly differentiated, except the terminal one. Sarcotesta red to brownish red when ripe. Sclerotesta ellipsoid to ovoid, 20–33 mm (0.8–1.3 in) long, 17–23 mm (0.7–0.9 in) in diameter. Male cones usually solitary but sometimes as many as three, subcylindrical, 16–20 cm (6.3–8 in) long, 3–7.5 cm (1.2–3 in) in diameter, greenish to orange-yellow. Peduncle 8–21 cm (3.2–8.3 in) long, 8–20 mm (0.3–0.8 in) in diameter. Median sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 14–18 mm (0.6–0.7 in) high, 18–26 mm (0.7–1 in) wide, the facets often poorly differentiated, the central facet drawn out, beak-like, projecting 10–12 mm (0.4–0.5 in). Sporangia in a somewhat heart-shaped patch. Habitat: Dry savanna with tall grass as the dominant plant, at elevations of 1000–2000 m (3300–6600 ft). Rainfall averages 1500–2000 mm (59–79 in) annually. The average temperature is 25°C (77°F) in January, 23°C (73°F) in July. Distribution: Democratic Republic of the Congo (Zaire), Lualaba-Kasai and Bas-Katanga districts. Angola, northeastern part of the country along the border with Zaire (?).

Between December 1875 and October 1876, Paul Pogge, a German botanist, traveled in the Belgian Congo collecting plants. He returned from this expedition with more than 400 specimens, one of which was an unknown cycad. This cycad was brought to the attention of Paul Friedrich August Ascherson, another German botanist, who in 1878 named the plant *Encephalartos poggei* in honor of its discover. Then in 1891 a Captain Lemarinel (evidently a Belgian army officer) discovered a small cycad on the right bank of the Lubi River in the southern portion of the Belgian Congo. He brought this discovery to the attention of two Belgian botanists, Émile Auguste Joseph de Wildeman and Théophile Alexis Durand, who worked with the Colonial Garden of the Congo State at Laeken, Belgian Congo. In 1900 these two botanists named this cycad *E. lemarinelianus* in honor of Captain Lemarinel. It was discovered sometime later that this name was based on the same population that had previously been named *E. poggei* and thus became a synonym.

As with a number of other central African species, living material of *Encephalartos poggei* is not easily obtained. Although this species is a relatively decorative cycad it has one decided flaw, that being its deciduous nature. In habitat, the plants defoliate annually during the hot season (if not because of the annual fires), fresh leaves appearing after the start of the rains. This habit is common to a number of the cycads inhabiting grassland. Its small stature makes it a better plant for private gardens with space constraints. Cultivated with abundant water, specimens often tend to lose their deciduous habit. This cycad has not been very cold tolerant in my experience. Two small plants in my collection succumbed after an exceptionally cold winter with temperatures falling to −4°C (25°F).

It appears that *Encephalartos poggei* would be fairly fast growing when propagated from seed. Regrettably, seed is seldom if ever available. Few plants have ever been placed in cultivation, and those that have usually have been solitary specimens, which has made production of viable seed impossible.

David Prain (1917) stated that *Encephalartos poggei* had no economic value and was not used as an article of food. However, François Malaisse et al. (1990) reported the use of *E. poggei* as a food item by the Lunda.

According to the scant information available, *Encephalartos poggei* would apparently be considered as not threatened. As recently as 1974, numerous large colonies were reported to the south and southeast of Kananga, Zaire. Prior to that it was also reported from an area some 375 km (230 miles) northeast of Kananga, and unconfirmed reports place it across the border in northeastern Angola. This huge range would suggest that large numbers of *E. poggei* must still exist in the wild.

Encephalartos princeps R. A. Dyer 1965a

PLATES 325, 326

Quoting Robert Allen Dyer from his original description of *Encephalartos princeps,* "The specific epithet was chosen because it reflects the thought that *E. princeps* has had a longer history and has a more stately habit than its near allies *E. lehmannii* and *E. trispinosus.*" Stems arborescent, erect, solitary but almost always suckering from the base to form clumps, to 3 m (10 ft) tall, rarely as tall as 6 m (20 ft), 20–30 cm (8–12 in) in diameter. Leaves numerous, relatively straight or recurving in upper third, with a bluish or silvery bloom for a considerable period of time, dull green with age, 1–1.3 m (3.3–4.3 ft) long, 14–21 cm (5.5–8.3 in) wide. Petiole 15–26 cm (6–10 in) long, 1–1.2 cm (0.4–0.5 in) in diameter, base swollen and light brown. Leaflets in the upper half of the leaf in a V formation and upwardly overlapping in the top third, in the lower half of the leaf relatively flat, basal leaflets reduced in size but not to prickles, median leaflets 15–19 cm (6–7.5 in) long, 1.3–2 cm (0.5–0.8 in) wide, with a pungent apex, margins entire or occasionally toothed on the lower edge. **Female cones** one to three, barrel shaped to ovoid, 30–40 cm (12–16 in) long, 20–25 cm (8–10 in) in diameter, dull olive green, with a rounded apex. Peduncle short, cone appearing sessile. Median sporophylls about 6–7 cm (2.4–2.8 in) long. Sporophyll face 3–3.5 cm (1.2–1.4 in) high, 4–4.5 cm (1.6–1.8 in) wide, protruding 2–2.5 cm (0.8–1 in), indistinctly ridged but coarsely and irregularly pimpled, the terminal facet covered with sparse whitish or brownish hairs. Sarcotesta red when ripe. Sclerotesta short ovoid, 24–26 mm (0.9–1 in) long, 16–19 mm (0.6–0.7 in) in diameter, light brown, smooth except for 8–10 indistinct longitudinal grooves. Chalaza 9–10 mm (0.3–0.4 in) long, 8–9 mm (0.3–0.4 in) wide, with very small shallow pits. **Male cones** one to three, subcylindrical, 16–26 cm (6.3–10 in) tall, 8–10 cm (3.2–4 in) in diameter, narrowing toward both ends, dull olive green. Peduncle about 4 cm (1.6 in) long, hidden among the cataphylls. Median sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face 5–6 mm (0.2 in) high, 15–18 mm (0.6–0.7 in) wide, projected into a beak 12–15 mm (0.5–0.6 in) long. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Usually on doleritic outcrops and cliffs at elevations of about 770 m (2500 ft). The habitat is very desertlike with an annual rainfall of 450–500 mm (18–20 in). Summers are very hot, and winters very cold. **Distribution:** South Africa, Eastern Cape province, Butterworth, Cathcart, Komga, Tsomo, and Queenstown districts, in the catchment areas of the Kabousie and Kei Rivers.

Encephalartos princeps was included in the concept of *E. lehmannii* until 1965 when Robert Allen Dyer described it as a separate species. The species differ in a number of respects. *Encephalartos lehmannii* seldom exceeds 1.5 m (4.9 ft) in stem height and is erect whereas *E. princeps* grows to 3–5 m (10–16 ft) tall and is generally leaning or decumbent. In *E. lehmannii* the leaflets are flatly inserted into the rachis whereas in *E. princeps* they overlap in an upward direction in the top third of the leaf. The petiole base of *E. lehmannii* is swollen, exposed, and has a distinctive tan or brown collar, whereas in *E. princeps* it is small and usually covered by the stem cataphylls. The cones of *E. lehmannii* are solitary and blackish red to green whereas *E. princeps* carries as many as four olive green cones. The ranges of the two species do not overlap, and *E. lehmannii* grows on sandstone formations whereas *E. princeps* seems to prefer doleritic outcrops. In other respects their habitats are similar. It has been reported that *E. princeps* grows with *E. friderici-guilielmi* in the southwestern part of the Queenstown district, Eastern Cape, but no hybrids have been observed.

Encephalartos princeps grows well in cultivation if given well-drained soil and a sunny location. It is a handsome plant with its crown of numerous bluish or silvery leaves. It will withstand several degrees of frost without apparent harm. This species grows well from seed and can be considered fast growing when given proper conditions. Seed is not readily available, however, making this cycad somewhat difficult to obtain. In its habitat, *E. princeps* exhibits a reluctance to cone except after exceptionally wet seasons. Those periodic wet years are infrequent, therefore natural seed production is irregular. In southern California, too, I have found it somewhat reluctant to cone. Collectors or botanical gardens with coning individuals should make every effort to produce viable seed.

Encephalartos princeps has a reasonably large range and is considered common in some areas. In more recent years, however, large numbers have been removed for cultivation. For this reason, *E. princeps,* as true of most other Cape cycads, must be considered threatened.

Encephalartos pterogonus R. A. Dyer & I. C. Verdoorn 1969

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The epithet for *Encephalartos pterogonus* is derived from *pteron,* Greek for wing, and *gone,* a reproductive structure, referring to the distinctive winglike and toothed appendages below the terminal facet on the microsporophylls. **Stems** erect, solitary or suckering from the base to form clumps, to about 1.5 m (4.9 ft) long and 40 cm (16 in) in diameter. Cataphylls narrowly ovate, acuminate, woolly when young. **Leaves** numerous, oblong elliptical, suberect, then spreading, 1.2–1.5 m (3.9–4.9 ft) long, 30–36 cm (12–14 in) wide, flat, abruptly narrowed at the apex and gradually narrowed toward the base. Petiole 4–8 cm (1.6–3.2 in) long, 2.5–3 cm (1–1.2 in) in diameter, woolly toward the expanded base, 6–7 cm (2.4–2.8 in) wide. Rachis straight. Leaflets dark green, stiff, crowded and overlapping, especially in the upper half of the leaf, directed forward in a V formation, basal leaflets gradually reduced to prickles, median leaflets 15–18 cm (6–7.1 in) long, 2–2.5 cm (0.8–1 in) wide, spaced 1.5–2 cm (0.6–0.8 in) apart, somewhat unequally narrowing at the base, apex usually upturned, pungent, margins flat to slightly revolute, each with one or two strong prickles toward the base. **Female cones** usually two or three, barrel shaped to subcylindrical, 35–40 cm (14–16 in) long, 16–18 cm (6.3–7.1 in) in diameter toward the base, glossy bright green, glabrous. Peduncle about 8 cm (3.2 in) long, woolly. Median sporophylls 4–4.5 cm (1.6–1.8 in) long. Sporophyll face 2.5–3 cm (1–1.2 in) high, 4.5–5.5 cm (1.8–2.2 in) wide, the lateral angles sometimes protruding more than the terminal facet, sometimes slightly toothed, curved inward into lobes about 1 cm (0.4 in) long, upper facet humped to a height of about 1 cm (0.4 in), lower facet rough on the inner margin, terminal facet about 1.5 cm (0.6 in) high, 2–2.5 cm (0.8–1 in) wide. Sarcotesta scarlet to orange-red when ripe. Sclerotesta 28–35 mm (1.1–1.4 in) long, 19–22 mm (0.8–0.9 in) in diameter, smooth, with 6–11 indistinct longitudinal ridges. Chalaza not distinct, 10–11 mm (0.4 in) long, 7–8 mm (0.3 in) wide. **Male cones** usually one to three, narrowly ovoid oblong, 30–38 cm (12–15 in) long, 10–11 cm (4–4.3 in) in diameter. Peduncle 7.5–10 cm (3–4 in) long, with a woolly covering. Median sporophylls triangular cuneate, 3.5–4.5 cm (1.4–1.8 in) long, spreading horizontally. Sporophyll face 1.5–2 cm (0.6–0.8 in) high, 4–4.5 cm (1.6–1.8 in) wide, protruding 1–1.5 cm (0.4–0.6 in), lateral angles protruding beyond the terminal facet, winglike and often toothed or lobed, yellowish, the upper facet slightly humped, the terminal facet 12–15 mm (0.5–0.6 in) high, 15–20 mm (0.6–0.8 in) wide. Sporangia in a single somewhat Y-shaped patch. **Habitat:** On or near granite outcrops, usually along the fringes of evergreen woodland. **Distribution:** Mozambique, known only from Mount Mruwere north of Chimoio (Vila Pery).

Raymond Munch of Rusape, Southern Rhodesia (now Zimbabwe), was the first collector to bring *Encephalartos pterogonus* into cultivation about 1949. It was during a visit to Munch's garden in 1966 that Robert Allen Dyer and Inez Clare Verdoorn obtained the material that made the description of this species possible. Munch produced large quantities of seed from the plants in his collection, much of which was sent to interested parties overseas. We must hope that someone with documented plants will take an interest in producing seed of this species once again.

Encephalartos pterogonus is not remarkable other than for its very limited distribution and unusual male cone. The sporophylls of the male cone are unique because of the fringe of yellow teeth on the lower margin of the terminal facet. The leaves are not very different from those of *E. manikensis.* This cycad is worthy of cultivation but does not exhibit the difference in leaf structure that one comes to expect in the genus. Because of this, *E. pterogonus* is difficult to separate from other members of the *E. manikensis* complex unless cones are present. *Encephalartos pterogonus* is easy to grow as long as the winters are mild. In the area of Los Angeles, California, *E. pterogonus* normally defoliates in winter unless given some overhead protection. My specimens lose almost all their leaves each winter but soon replace them with the advent of warmer weather. In areas that do not experience frost, there should be no problems.

It has been difficult to conduct fieldwork because of past political conditions in Mozambique, so the habitat of *Encephalartos pterogonus* was not visited by botanists for some time. Because of this and the attendant lack of more recent data, it is difficult to ascertain the conservation status of this cycad. Since its range is so limited, *E. pterogonus* should be considered extremely endangered. One botanist who visited the area in the 1970s was unable to locate a single specimen, and all evidence available indicates that *E. pterogonus* may be extinct in the wild.

Encephalartos relictus P. J. H. Hurter 2002

The epithet for *Encephalartos relictus* is Latin for left behind, referring to the discovery of the last remaining individual of this species. **Stems** erect, arborescent, suckering from the base, to 2.5 m (8.2 ft) long, 40–45 cm (16–18 in) in diameter, crown and cataphylls densely golden brown tomentose, becoming subglabrous with age. **Leaves** numerous, rigid, spreading, subsessile, lavender blue, at first densely golden brown tomentose, then subglabrous with age, 1.1–2 m (3.6–6.6 ft) long. Petiole rarely more than 15 cm (6 in) long, densely golden brown woolly except for the base, becoming subglabrous with age. Rachis straight except for the slightly inwardly curved apex. Leaflets golden brown woolly, becoming subglabrous with age, veins prominently raised below, angled forward about 60°, opposing leaflets at angle of about 40° to each other, producing a V-shaped cross section, overlapping in a downward direction, basal leaflets gradually reduced to a few prickles, median leaflets 20–25 cm (8–10 in) long, 14–17 mm (0.6–0.7 in) wide, oblong lanceolate, pungent, with 20–25 prominent veins on the lower side only, margins entire and slightly thickened.

Female cones not described. Male cones generally one to three per crown, subconical, 20–24 cm (8–9.5 in) long, 12–15 cm (4.7–6 in) in diameter, light greenish yellow, glabrous, the facets smooth. Sporophylls 3.5–4 cm (1.4–1.6 in) long, spreading, more or less at right angles to the cone axis. Sporophyll face 1–1.5 cm (0.4–0.6 in) high, 3–3.5 cm (1.2–1.4 in) wide, the terminal facet projecting slightly as a drooping hooklike structure, the edges rough and warty. Sporangia in a butterfly-shaped patch. Habitat: Mixed deciduous woodland at an elevation of about 1000 m (3300 ft). Distribution: Historically, Swaziland, near Siteki (Stegi) on the farm Muti-Muti.

The history of *Encephalartos relictus* is very similar to that of *E. woodii* as both cycads were represented in the wild by only a single surviving male plant with numerous offsets. From the information that is available, J. J. P. du Preez discovered what was to become *E. relictus* in 1971 near the eastern border of Swaziland with Mozambique. This specimen was subsequently removed from habitat and planted in a private garden in South Africa. Numerous searches of the surrounding country since its discovery have not revealed any additional specimens. It is now generally accepted that *E. relictus* is extinct in the wild.

The closest relatives of *Encephalartos relictus* appear to be *E. heenanii* and *E. paucidentatus,* based on the similarity of the prominently raised veins on the underside of the leaflets. Another similarity between these three species is the copious amount of tomentum in the crown and on the emergent leaves. One other species that may be more distantly related is *E. transvenosus. Encephalartos relictus* has lavender blue leaves, entire leaflets, and glabrous cones whereas the other three species have green leaves, leaflets with some marginal spines, and tomentose cones.

Encephalartos relictus does not seem to pose any problems in cultivation. One would expect *E. relictus* to be grown as easily as *E. heenanii, E. paucidentatus,* and *E. transvenosus.* Cultivated, the original plant has grown strongly and produced numerous offsets. Reports are that some offsets removed from the parent plant over the years have also grown well. *Encephalartos relictus* is extinct in the wild.

Encephalartos schaijesii Malaisse, Sclavo & Crosiers 1992

PLATES 330, 331

Encephalartos schaijesii is named in honor of Michel Schaijes, whose collection near Kolwezi, Democratic Republic of the Congo (Zaire), has advanced the knowledge of plants in that region. Stems more or less subterranean and suckering to form large clumps, individual stems 11–25 cm (4.3–10 in) above ground, 20–33 cm (8–13 in) in diameter, the exterior covered with a persistent beige-red tomentum. Cataphylls 35–95 mm (1.4–3.7 in) long, 5 mm (0.2 in) wide. Leaves usually 6–13, more or less erect, green to bluish green, 0.8–1.2 m (2.6–3.9 ft) long, oblong, rapidly narrowing toward the base, strongly keeled. Petiole about 20 mm (0.8 in) long, 8–10 mm (0.3–0.4 in) in diameter, the swollen base with a persistent tomentum. Leaflets in 48–58 pairs, angled forward 70–75°, base yellow-green and narrowed to 5–6 mm (0.2 in), basal leaflets rapidly reduced to 7–10 pairs of spines, median leaflets oblong, 125–167 mm (5–6.6 in) long, 14–18 mm (0.6–0.7 in) wide, margins flat with none or one spine on the upper margin, one to three spines on the lower, the spines 2–4 mm long and yellow-green, the leaflet apex with a terminal spine 1–2 mm long. Female cones solitary, erect, ellipsoid, 29–32 cm (11–13 in) long, 12.5–15 cm (5–6 in) in diameter, green to gray-green or yellowish green. Peduncle 1–1.5 cm (0.4–0.6 in) long, 4–4.5 cm (1.6–1.8 in) in diameter. Median sporophylls with the facets distinct, the terminal facet rhomboid, lateral facets trapezoidal, medial facet triangular, and a distinct medial ridge. Sporophyll face 4–4.5 cm (1.6–1.8 in) high, 5.5–6 cm (2.2–2.4 in) wide, projecting about 2 cm (0.8 in). Male cones solitary, ellipsoid to subcylindrical, 15–17 cm (6–6.7 in) long, 4–4.5 cm (1.6–1.8 in) in diameter when dry, yellowish green. Peduncle 10–15 mm (0.4–0.6 in) long, 5 mm (0.2 in) in diameter. Median sporophylls 15–17 mm (0.6–0.7 in) long, inclined 75–80°, the terminal facet rhomboid, lateral facets trapezoidal, median facet rectangular with a distinct medial ridge. Sporophyll face 12–15 mm (0.5–0.6 in) high, 12–18 mm (0.5–0.7 in) wide, projecting 5–7 mm (0.2–0.3 in). Sporangia in a single irregular patch. Habitat: Wooded savanna composed of *Albizia antunesiana, Brachystegia spiciformis,* and *Terminalia,* similar to the steppelike savannas on the sands of the Kalahari Desert, at an elevation of about 1500 m (4900 ft). Distribution: Democratic Republic of the Congo (Zaire), Shaba administrative district, near the village of Kolwezi.

François Malaisse, Jean-Pierre Sclavo, and Catherine (Crosiers) Moretti described *Encephalartos schaijesii* in 1992. Michel Schaijes, for whom the plant is named, a resident of Kolwezi, southeastern Zaire, who has collected plants in the area for many years, assisted in the botanical investigation. The closest relative of *E. schaijesii* appears to be *E. poggei,* also a small cycad, which occurs some distance to the west of *E. schaijesii* in Zaire and inhabits the same general type of habitat, namely, savanna and open grassland. The two can be distinguished from each other by several characters. *Encephalartos schaijesii* has strongly keeled rather than flat leaves, yellowish green rather than yellow cones, and occurs in clumps of 5–20 stems as opposed to the generally single stem of *E. poggei.*

Encephalartos schaijesii is a very rare cycad and I doubt there are any specimens outside Zaire. Within its range, it occurs as scattered specimens, usually forming clumps by suckering from the base. It is not a large cycad, and for this reason, if sufficient material of *E. schaijesii* were available it would no doubt become a popular collector's or garden plant. It is hoped that additional field investigations will disclose colonies larger than those known, and that seed can be collected so as to introduce this species into cultivation.

Since its elevation of occurrence is about 1500 m (4900 ft) we might expect *Encephalartos schaijesii* to have some frost tolerance. We can be sure that *E. schaijesii* would grow well in tropical and semitropical environments, but it should be carefully monitored in areas subject to frost. Specimens that have been transplanted within Zaire have reestablished without problems, and we can expect *E. schaijesii* to react to cultivation in the same way as other tropical grassland cycads. *Encephalartos schaijesii* must be considered endangered until such time as additional colonies may be discovered, and its entire range determined.

Encephalartos schmitzii Malaisse 1969

PLATES 332, 333

Encephalartos schmitzii is named in honor of André Schmitz (b. 1920), who discovered this cycad. **Stems** generally subterranean, older plants arborescent and suckering profusely from the base, stems erect or decumbent in larger specimens, seldom branched, to 1.5 m (4.9 ft) long and 15 cm (6 in) in diameter, crown covered with gray-white tomentose cataphylls. **Leaves** 8–25, straight to slightly arching, glaucous green to green, 0.5–1.2 m (1.6–3.9 ft) long, 10–13 cm (4–5.1 in) wide, strongly keeled, the petiole and rachis glabrous. Petiole lacking or as much as 1–2 cm (0.4–0.8 in) long, 7 mm (0.3 in) in diameter, base triangular in cross section. Leaflets in 44–52 pairs, linear lanceolate, median leaflets 10–15 cm (4–6 in) long, 8–15 mm (0.3–0.6 in) wide, glabrous, margins either entire or with none or one spine on the upper margin and two to five spines on the lower, usually close to the base of the leaflet, the spines 1–2 mm long, the lower margin slightly decurrent. **Female cones** solitary, erect, ovoid cylindrical, 24–35 cm (9.4–14 in) long, 10–15 cm (4–6 in) in diameter, glaucous green to dark green, becoming yellowish at maturity, glabrous. Peduncle short, the cone appearing sessile. Median sporophylls glabrous. Sporophyll face 2.5–3 cm (1–1.2 in) high, 5–5.5 cm (2–2.2 in) wide, the surface slightly wrinkled, the facets more or less obscure except the terminal one. Sarcotesta orange when ripe, brownish yellow when dry. Sclerotesta ovoid, somewhat angled, 2.5–3 cm (1–1.2 in) long, 2–2.5 cm (0.8–1 in) in diameter. **Male cones** one to three, erect, ovoid to narrowly ovoid, 12–23 cm (4.7–9.1 in) long, 3.5–7 cm (1.4–2.8 in) in diameter, dark green, becoming greenish yellow with age, glabrous. Peduncle 2.5–6 cm (1–2.4 in) long but the cone appearing sessile. Median sporophylls with the upper surface concave and the entire surface slightly wrinkled. Sporophyll face 7–10 mm (0.3–0.4 in) high, 15–20 mm (0.6–0.8 in) wide. Sporangia in a single heart-shaped patch. **Habitat:** Dry savanna steppe and open forest, usually in sandy soil, at elevations of 200–600 m (660–2000 ft). **Distribution:** Democratic Republic of the Congo (Zaire), Haut-Katanga district, Kundelungu Plateau. Zambia, catchment of the Luapula River.

What was to become *Encephalartos schmitzii* was discovered in 1955 by André Schmitz, at the time director of the Laboratory of Silviculture at the University of the Congo, while on a botanical expedition. Only a few specimens had been found and it was thought possible that it was a relict species. The plants were considered similar to the better known *E. caffer* of South Africa because of their subterranean stems. At the same time, botanists from the Salisbury Royal Herbarium, Southern Rhodesia (now Harare, Zimbabwe), discovered cycads growing along the Muchinga escarpment in the Northern province of Zambia. The identity of these cycads was not disclosed until an expedition to the Mpika region of Zambia by Jean-Pierre Sclavo, his wife, Odile, and Ian Turner, who discovered a single large female plant of *E. schmitzii* on 12 January 1986. This remarkable find extended the known range of *E. schmitzii* some 400 km (250 miles). Then in 1996 a South African botanist, Johan Hurter, reported an extensive colony of *E. schmitzii* in adjacent Zambia. That colony was estimated to contain more than 5000 plants, with several smaller colonies in the same district. Unlike the original reports, which indicated *E. schmitzii* as stemless, some of these later discovered plants have stems well over 1 m (3.3 ft) long.

The closest relatives of *Encephalartos schmitzii* are thought to be *E. delucanus* and *E. marunguensis.* In fact, at least one botanist believes these three to be the same species. The study of these species is hampered by the rarity of the plants and the difficult terrain in which they grow. As more research is carried out on *Encephalartos* in central Africa, we must hope that these taxa can be properly compared.

Encephalartos schmitzii is quite rare in collections, doubtless the result of its growing in remote areas. The few specimens I have seen in cultivation were in the collection of Ian Turner, who lives near Harare. His specimens of *E. schmitzii* were growing and coning well and did not seem to pose any horticultural problems. I am not aware of any viable seed having been collected in habitat or produced from cultivated plants. It is hoped that such seed production will take place, increasing the number of plants in cultivation. As *E. schmitzii* is a small, handsome cycad, it could become popular with collectors and in public gardens. On the other hand, *E. schmitzii* is a grassland cycad, which generally do not make good horticultural subjects because of their deciduous habit. In cultivation, some grassland species such as *E. caffer* and *E. cycadifolius* seem to lose their deciduous habit and hold leaves all year. It will be some time before we know just how *E. schmitzii* reacts to cultivation.

The conservation status of *Encephalartos schmitzii* has changed with the discovery of the large populations in Zambia. These populations do not appear to be under pressure from agriculture or other land use. Therefore, *E. schmitzii* can be considered as not threatened.

Encephalartos sclavoi De Luca, D. W. Stevenson & Moretti 1989

PLATE 334

Encephalartos sclavoi is named in honor of Jean-Pierre Sclavo, French student of cycads who first recognized this cycad as an unknown species. Stems arborescent, erect though larger stems usually decumbent, suckering from the base to form clumps with two to six stems, mature specimens 1–4 m (3.3–13 ft) tall, 30–35 cm (12–14 in) in diameter, crown packed with grayish tomentose cataphylls. Leaves numerous, straight, erect, oblong, 1.8–2 m (5.9–6.6 ft) long, 30–40 cm (12–16 in) wide, flat. Petiole 10–15 cm (4–6 in) long, 2.2–3 cm (0.9–1.2 in) in diameter, its base swollen and tomentose. Rachis straight or slightly twisted, glabrous or very lightly tomentose, with two shallow longitudinal grooves between the leaflet insertions. Leaflets alternate to subopposite, strongly leathery, dark green or blue-green, yellow at the attachment, angled forward slightly, the leaflets twisted so as to be arranged obliquely overlapping in a downward direction and appearing as a half-opened venetian blind, generally with a median longitudinal fold running the length of the leaflet, basal leaflets gradually diminishing in size and abruptly becoming spiny in the last three to five leaflet pairs, median leaflets oblong to elliptical, the halves slightly unequal, 18–28 cm (7.1–11 in) long, 3–5 cm (1.2–2 in) wide, apex pungent and curved backward and downward so as to appear hooklike, margins strongly revolute, both the upper and lower with none to three short spiny teeth, often reduced to bumps of callus on the basal half. Female cones cylindrical to ovoid cylindrical, 30–40 cm (12–16 in) long, 15–35 cm (6–14 in) in diameter, yellow to tan when mature, glabrous. Peduncle erect, 2–4 cm (0.8–1.6 in) long, 2–3 cm (0.8–1.2 in) in diameter. Median sporophylls about 4 cm (1.6 in) long. Sporophyll face rhomboid, 38–40 mm (1.5–1.6 in) high, 55–65 mm (2.2–2.6 in) wide, projecting 10–13 mm (0.4–0.5 in), the terminal facet hexagonal and slightly concave. Sarcotesta deep red when ripe. Sclerotesta short to long ovoid, 32–44 mm (1.3–1.7 in) long, 19–23 mm (0.8–0.9 in) in diameter, smooth except for 12–14 indistinct longitudinal ridges. Male cones usually one to three, subconical, 20–40 cm (8–16 in) long, 15–25 cm (6–10 in) in diameter, yellow to pinkish yellow when mature. Peduncle erect, 9–12.5 cm (3.5–4.9 in) long, 4–5 cm (1.6–2 in) in diameter. Median sporophylls deltoid, 2.5 cm (1 in) long. Sporophyll face 16–20 mm (0.6–0.8 in) high, 28–38 mm (1.1–1.5 in) wide, at right angles to the cone axis, the terminal facet deflexed. Sporangia in a single somewhat irregular patch. Habitat: Steep, relatively dry, south-facing rocky slopes in grassland, at elevations averaging 1800–2100 m (5900–6900 ft). Rainfall is reported as high, falling mainly in summer. Distribution: Tanzania, northeastern part of the country, western Usambara Mountains, Tanga district, Gologolo near Lushoto.

The existence of *Encephalartos sclavoi* was known for many years before it was described botanically. Ronald Melville (1958) made the first mention of it in his treatment of *Encephalartos* in the *Flora of Tropical East Africa,* in which two recently described species were included, *E. bubalinus* and *E. tegulaneus,* and in which an imperfectly known cycad was mentioned as species "A." That latter was based on a collection, *Robert Bailey Drummond & James Hafton Hemsley 1372,* made in the western Usambara Mountains on March 1, 1953. It was once again mentioned by Denis Heenan in 1977 after a collecting trip to central Africa. Then in January 1986 a French student of cycads, Jean-Pierre Sclavo, while prospecting for plants in Tanzania, recognized it as worthy of description. His notes and herbarium specimens were turned over to Aldo Moretti of the University of Naples, Italy, leading to the description of *E. sclavoi* in 1989 (the description republished by Stevenson et al. 1990 with the authorities given as Stevenson, Moretti & De Luca).

Encephalartos sclavoi is one of the most distinctive and handsome cycads of eastern central Africa. The broad leathery leaflets, with their strongly revolute margins and downward overlapping arrangement, make it easily identifiable even in the absence of cones. It is difficult to believe that such a remarkable cycad could be described at such a late stage in the botanical exploration of central Africa. I was first privileged to see a specimen at the home of its discoverer, Jean-Pierre Sclavo, during the first symposium on cycad research, Cycad 87, in Nice, France. It was newly established but even so it was the center of attention to all who saw it.

Encephalartos sclavoi is a most rewarding plant in cultivation. Its beauty and ease of horticulture make it one of the finest cycads for use in the garden. Even though the habitat of *E. sclavoi* is close to the equator, the high elevation at which it occurs gives it a remarkable degree of cold tolerance. It can also be grown in full sun without its leaves burning. As a garden plant, this cycad will usually hold two or three crowns of leaves, all in good condition.

The conservation status *Encephalartos sclavoi* at first appears to be secure. Colonies are large, and regeneration in habitat is prolific, with many seedlings and immature plants in evidence. This could change rapidly, however, because the habitat is located in a prime forestry and agriculture area. The climate in the area is mild, because of the elevation, and is considered one of the finest areas in which to live in Tanzania. An increase in human settlement and subsequent change in land use could cause conservation problems for this cycad.

Encephalartos senticosus Vorster 1996d

PLATES 335, 336

The epithet of *Encephalartos senticosus* is Latin, meaning full of thorns or prickles, referring to the spiny margins of the leaflets. **Stems** arborescent, erect or leaning, often suckering from the base to form clumps, to 4 m (13 ft) long and 30 cm (12 in) in diameter, crown somewhat woolly. **Leaves** numerous, erect, straight to curved somewhat backward and downward at the apex, rigid, 1.1–2 m (3.6–6.6 ft) long, 16–28 cm (6.3–11 in) wide. Petiole glabrous, 5–20 cm (2–7.9 in) long, 15–18 mm (0.6–0.7 in) in diameter. Leaflets dark glossy green, generally not overlapping in a downward direction, angled forward about 30°, opposing leaflets at an angle of about 135° to each other, producing a V-shaped cross section, basal leaflets reduced to spines, median leaflets narrowly lanceolate, 12–18 cm (4.7–7.1 in) long, 14–22 mm (0.6–0.9 in) wide, spaced 2–2.5 cm (0.8–1 in) apart, margins usually toothed, often with more spines on the lower edge than on the upper, rarely entire, apex acute and pungent. **Female cones** usually two or three per crown, ovoid, 40–45 cm (16–18 in) long, 22–30 cm (8.7–12 in) in diameter, pale apricot yellow when mature, the surface sparsely covered with short feltlike tomentum. Peduncle short, cone appearing sessile. Sporophylls 5.5–6 cm (2.2–2.4 in) long, their exposed areas smooth and pyramidally raised toward the central facet, lateral facets indistinct. Sporophyll face 35–40 mm (1.4–1.6 in) high, 45–50 mm (1.8–2 in) wide, projecting 10–12 mm (0.4–0.5 in). Sarcotesta bright red when ripe. Sclerotesta ovoid, 24–29 mm (0.9–1.1 in) long, 19–20 mm (0.7–0.8 in) in diameter, with 12–14 indistinct longitudinal ridges. Chalaza 7–9 mm (0.3–0.4 in) in diameter. **Male cones** usually three or four per crown, erect, narrowly ovoid, 30–50 cm (12–20 in) long, 12–15 cm (4.7–6 in) in diameter, orange to orange-yellow when mature, covered with a sparse light brown tomentum. Peduncle to 10 cm (4 in) long, 2.5–4.5 cm (1–1.8 in) in diameter. Sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face rhombic, 15–18 mm (0.6–0.7 in) high, 35–40 mm (1.4–1.6 in) wide, drawn out into a prominent drooping beak toward the central facet, the central facet well defined, others indistinct. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Dry, exposed cliffs or more commonly on gentle slopes among boulders and in brush clumps, generally in direct sunlight, most commonly at elevations of 400–800 m (1300–2600 ft). Rainfall averages 625–750 mm (25–30 in) annually, falling mainly in summer. **Distribution:** South Africa, northern KwaZulu-Natal province, Lebombo Mountains from south of the Josini Dam northward to a few kilometers beyond Siteki (Stegi), Swaziland.

Encephalartos senticosus was described in 1996 but was well known to both botanists and collectors for almost 50 years before. Mistaken identity kept the plants from being studied botanically. Inez Clare Verdoorn named *E. lebomboensis,* a closely related species, in 1949 from material collected in the Lebombo Mountains, Mpumalanga province, and from the Pongola River Valley, both in South Africa. (The Lebombo Mountains run north–south from the Northern province through Swaziland to KwaZulu-Natal.) From 1949 until the early 1990s all the larger cycads from the Lebombo Mountains were considered to be *E. lebomboensis.* When collectors became interested in these plants, they noticed that there were two distinct forms, *E. lebomboensis* and the Piet Retief form of *E. lebomboensis.* Several consistent features easily distinguished these two forms from each other. In the early 1990s, Piet Vorster, one of the leading cycad taxonomists of South Africa, decided to describe the Piet Retief form as a separate species. When he examined the type specimen of *E. lebomboensis* he was amazed to find that it was based on the cycad from the Piet Retief area. This meant that the cycad that had been accepted as *E. lebomboensis* for so many years was in fact the undescribed species, which he proceeded to describe in 1996 as *E. senticosus. Encephalartos senticosus* is not unique in having its identity mistaken for years. *Cycas taiwaniana* and *Zamia chigua* both have similar histories.

Encephalartos senticosus is an extremely robust and decorative plant for gardens and landscapes. It is undemanding in its growing conditions and will adjust to climatic conditions from temperate to tropical. It is usually unaffected by exposure to several degrees of frost, and leaf damage is generally not apparent at temperatures above −4°C (25°F). Although *E. senticosus* will grow in both shade and full sun, it seems to do better in sunny situations. Insect pests do not usually affect this cycad outside its native environs, but the larvae of a lepidopteran that will completely consume an entire crown of emerging leaves attack the plants in South Africa. Under cultivation in other countries, scale insects and mealybugs seem to be the most common pests.

Encephalartos senticosus is one of the most abundant of the South African cycads, and no doubt this is why it is so well represented in both botanical gardens and private collections worldwide. Regeneration in habitat is strong. Seed is usually viable, and a great deal of it has been used to bring plants into cultivation in more recent years.

A large-scale rescue operation known as Operation Wildflower was mounted in the mid-1960s, taking place in the area that was to be flooded by the completion of the dam at Pongola Poort, South Africa. The area above Josini on the Pongola River was home to thousands of *Encephalartos senticosus* (then misidentified as *E. lebomboensis*), and more than 6000 plants were rescued by this operation. The area was opened to botanists, botanical gardens, plant collectors, and other interested persons for rescue of the cycads as well as other rare plants. In this way, many plants were saved that otherwise would have been submerged by the rising water. This was a very commendable undertaking and it is hoped that its success will not be forgotten when other areas containing cycads or other rare plants are scheduled for development.

The conservation status of *Encephalartos senticosus* in 1996 seemed quite secure. Even though a vast number of plants were lost with the filling of the lake created by the Josini Dam, and thousands more have been removed from their habitat for landscaping and collections, the cycad remains relatively common in the Lebombo Mountains. A conservation status of threatened would seem prudent.

Encephalartos septentrionalis Schweinfurth 1871

PLATES 337–339

Encephalartos septentrionalis, the epithet Latin for north or northern, referring to this cycad's being one of the northernmost of the central African species, is called *kagga-kunda* by the Bongo tribe, *kotto* by the Kredj-Nduggu tribe, and *mwue-piah* by the Niam-Niam tribe. **Stems** globose and generally subterranean or to a height of 2 m (6.6 ft), 25–30 cm (10–12 in) in diameter. **Leaves** numerous, straight, narrow oblong, tapering gradually toward the base, light green to gray-green, 0.9–1.5 m (3–4.9 ft) long, 28–45 cm (11–18 in) wide, flat, emergent foliage densely gray tomentose, then glabrous with age. Petiole 2.5–5 cm (1–2 in) long or sometimes completely lacking. Rachis distinctly grooved between the leaflets. Leaflets in 40–50 pairs, oblong to lanceolate, sometimes falcate, more or less leathery, angled forward about 80°, moderately spaced, basal leaflets 5–9 mm (0.2–0.4 in) wide at the attachment, reduced to spines, median leaflets 7.5–18 cm (3–7.1 in) long, 1.5–3.5 cm (0.6–1.4 in) wide, margins with two to seven spiny teeth, often crowded together near the leaflet base, the upper margin more or less straight, the lower upcurved toward the forwardly directed spiny tip. **Female cones** solitary, pendulous, cylindrical, 23–35 cm (9.1–14 in) long, 18–20 cm (7.1–8 in) in diameter, blue-green when young, turning olive green, finally yellow-brown when mature. Peduncle 25–30 cm (10–12 in) long. Sporophylls 5.5–6 cm (2.2–2.4 in) long, the inner surfaces bright pinkish red when ripe. Sporophyll face 20–27 mm (0.8–1.1 in) high, 45–50 mm (1.8–2 in) wide, projecting 20–25 mm (0.8–1 in). Sarcotesta deep red when ripe. Sclerotesta ellipsoid to ovoid or subglobular, three- or four-angled, 23–34 mm (0.9–1.3 in) long, 16–24 mm (0.6–0.9 in) in diameter. **Male cones** as many as 8–10 per crown, narrowly ellipsoid or tapering in the upper half, 12–20 cm (4.7–8 in) long, 6–8 cm (2.4–3.2 in) in diameter, pale blue-green when young, turning olive green, finally dark yellow-brown at maturity. Peduncle 15–30 cm (6–12 in) long, 5–12 mm (0.2–0.5 in) in diameter. Sporophylls 23–29 mm (0.9–1.2 in) long. Sporophyll face 6–10 mm (0.2–0.4 in) high, 15–25 mm (0.6–1 in) wide, projecting 5–8 mm (0.2–0.3 in). Sporangia in a single somewhat heart-shaped patch. **Habitat:** Rocky areas in grassland and open bushland at elevations of 900–2400 m (3000–7900 ft). **Distribution:** Sudan, former Equatoria province, Zandeland, Imatong Mountains. Uganda, Acholi district, near Moyo.

Encephalartos septentrionalis was discovered and named by the German explorer and botanist Georg August Schweinfurth. He did a great deal of fieldwork in central Africa, especially in Sudan. In his notes he says, "In early February the plants put out their new foliage after being hidden like dormant bulbs due to the Savannah fires." Later, he mentioned that a plant sent to Berlin had not fared well and he thought it must die. He also stated, "I wanted to send a second specimen with an intact rootstock but found it has been completely bored through by a tunnelling insect." It would seem by this statement that boring cycad weevils are also present in Sudan. In a final statement, Schweinfurth said,

> If neither [John] Kirk or [Charles James] Meller in East Africa, nor [William Balfour] Baikie, [Charles] Barter or [Gustav] Mann in West Africa found something similar, and [given that] this plant differs from the Southern African Forms, it must be regarded as new. This being the case. I propose the name *Encephalartos septentrionalis* in order to record an important plant-geographical fact.

The phytogeographical fact that Schweinfurth wanted to make is that *E. septentrionalis* is the northernmost species of the genus in East Africa.

Encephalartos septentrionalis is another of the imperfectly known central African cycads. Ronald Melville (1957) in "*Encephalartos* of central Africa," after giving a description of *E. septentrionalis,* stated, "The above description has been pieced together from a number of collections, none of which was complete in itself." In this one sentence he addressed the main problem of many cycad taxa, that neither the collections nor the data are complete. There are a number of reasons for this. Remote plant populations in virtually inaccessible habitats often make return trips impossible. Many cycads cone sporadically, so the collection of both female and male cones is a matter of good luck rather than collecting expertise. In some cases, annual fires destroy not only the cones but the leaves as well, leaving nothing to collect. And so it goes.

It appears to me from the living material I have been able to study that the populations assigned to *Encephalartos septentrionalis* may represent more than a single species. The plants from Moyo, Uganda, are described as having larger stems, and those from the Imatong Mountains, Sudan, as having subterranean stems. These two colonies are separated by the Mobutu Nile, which flows northward out of Lake Mobutu Sese Seko (Lake Albert). The Imatong Mountains are located some 150 km (93 miles) from the colony at Moyo. Additional fieldwork with the collection of fresh material will be needed to clarify the correct taxonomy of these cycads.

Encephalartos septentrionalis is poorly represented in botanical gardens and private collections, mainly because of the difficulty of obtaining living material. This cycad does not exhibit a great deal of cold tolerance and therefore should not be grown unprotected in frost-prone areas. Three specimens of *E. septentrionalis* grew well in my garden for several years until a winter of prolonged freezing weather caused their untimely death. I have grown a number of seedlings of *E. septentrionalis* for 2 years. At first they appeared very weak, with the leaves unable to hold themselves erect, then they gained strength and the leaves started to grow erect. It will be interesting to note their growth in the years to come.

The conservation status of *Encephalartos septentrionalis* is difficult to assess. Schweinfurth stated in 1871 that he had observed hundreds of these cycads growing in savanna that was not good agricultural land. He also stated that the natives had no use for this plant but then mentioned that his porters said that a beerlike beverage was prepared by the Kredj-Nduggu tribe from the starch-rich central portion of the stems. If the populations of *E. septentrionalis* have not suffered over the intervening years, it is most probably not threatened. As recently as 1995, seed had been collected near Moyo and the colonies were reported as extensive and healthy.

Encephalartos tegulaneus Melville 1957

PLATES 340, 341

The epithet for *Encephalartos tegulaneus* is derived from *tegula,* Latin for tile or tiled roof, referring to the sporophylls of the male cone, which overlap like roof tiles. **Stems** arborescent, unbranched, erect or sometimes decumbent in older and larger specimens, 7–10 m (23–33 ft) tall, 30–55 cm (12–22 in) in diameter. Cataphylls acuminate lanceolate to linear, 8–18 cm (3.2–7.1 in) long, 5–

35 mm (0.2–1.4 in) wide, with an external thick covering of buff-colored tomentum. **Leaves** numerous, straight, stiff, linear oblanceolate, tapering slightly toward the rounded apex and gradually toward the base, 1.2–1.8 m (3.9–5.9 ft) long, 30–40 cm (12–16 in) wide. Petiole 15–25 cm (6–10 in) long, 35–39 mm (1.4–1.5 in) in diameter, base swollen and covered with brownish tan tomentum. Rachis distinctly grooved between the leaflets. Leaflets in 90–95 pairs, basal leaflets gradually reduced to simple spines, median leaflets oblong lanceolate, rigid, leathery, 16–22 cm (6.3–8.7 in) long, 16–28 mm (0.6–1.1 in) wide, margins abruptly curved backward and downward, entire or with one to three short spines near the base on the upper edge, one on the lower, the spines almost hidden below the leaflet because of the strongly revolute margins. **Female cones** one to four, cylindrical, 40–70 cm (16–28 in) long, 19–30 cm (7.5–12 in) in diameter, bright yellow at maturity, apex and base rounded. Peduncle about 9 cm (3.6 in) long and 3.5 cm (1.4 in) in diameter. Median sporophylls 23–32 mm (0.9–1.3 in) high, 50–60 mm (2–2.4 in) wide, the facets distinct. Sarcotesta deep pink to scarlet when ripe. Sclerotesta cylindrical to long ovoid, 30–37 mm (1.2–1.5 in) long, 16–18 mm (0.6–0.7 in) in diameter, light tan, smooth but with numerous almost invisible longitudinal ridges. Chalaza not distinct, 5–11 mm (0.2–0.4 in) long, 3–7 mm (0.1–0.3 in) wide, with small shallow pits. **Male cones** three to six, subcylindrical, 42–53 cm (16–21 in) long, 12–14 cm (4.7–5.5 in) in diameter, tapering abruptly toward the apex and gradually in the lower third to the base, bright yellow at maturity. Peduncle 20–30 cm (8–12 in) long, 2.5 cm (1 in) in diameter. Median sporophyll face 14–16 mm (0.6 in) high, 22–25 mm (0.9–1 in) wide, the facets distinct. Sporangia in a single somewhat heart-shaped patch. **Habitat:** Steep mountain slopes in association with cedar forest, large candelabra euphorbias, and *Podocarpus,* on exposed rock outcrops in bushland or in thick forest, sometimes near springs, at elevations of 1400–2300 m (4600–7500 ft). **Distribution:** Kenya, Northern Frontier province, Mount Warges in the Mathews Range, Mount Lolokwe about 56 km (35 miles) north of Isiolo, and reported from the Ndoto Mountains north of the Mathews Range.

Encephalartos tegulaneus has a very interesting history. It was discovered by a Smithsonian Institution botanical expedition to East Africa in 1911–1912. The original collection was from Mount Warges at the southern end of the Mathews Range, but incorrectly identified as *E. hildebrandtii.* Then, on May 7, 1954, it was rediscovered by a botanically interested wife of a game warden working in the area of Isiolo in the Northern Frontier province of Kenya. Her name was Joy Adamson, and she was well known for being the author of the popular book *Born Free,* a story describing the experience of raising orphaned lion cubs. Ms. Adamson collected herbarium specimens and seeds, took photographs, and made a watercolor sketch of the cycad in its habitat. These materials eventually reached the Royal Botanic Gardens, Kew, England, where Ronald Melville described it as a new species in 1957.

Some of the seed collected by Adamson was given to Peter Greensmith, director of the Parks Department in Nairobi. Greensmith raised a number of seedlings, which he intended to plant in the parks under his control. In 1959 I wrote to Greensmith, requesting material of *Encephalartos tegulaneus,* and he very generously sent me two seedlings, a welcome addition to my collection. They have proved to be quite hardy in Los Angeles, California, and have developed into massive plants. One plant produced three female cones in 2000.

Encephalartos tegulaneus is locally common in its habitat. It usually occurs as scattered individuals on steep mountainous terrain of very difficult access. Regeneration in habitat appears to be good, with many seedling plants in evidence. An interesting observation was published by Denis Heenan (1977) regarding this species, “a number of large decumbent specimens were found. These had been partially hollowed out lengthwise by the local Samburu herdsmen to form cattle drinking troughs and the plants were still living.” This is a good example of this cycad’s tenacious hold onto life. In 1993, several thousand viable seeds were collected in habitat and distributed worldwide. This single event has ensured the establishment of *E. tegulaneus* in cultivation and aided in the conservation of this interesting and beautiful cycad.

Encephalartos tegulaneus is easily grown and will accept, without complaint, a variety of soils and growing conditions. Growth rate is relatively rapid, and the plant is very robust. Cold tolerance is good, with plants taking several degrees of frost without showing leaf damage. This is doubtless a result of the high elevation of its natural habitat. The availability of this species is reasonably good, and it is hoped that the plants brought into cultivation, originally in the 1970s, will provide propagation material from which additional seed can be produced. *Encephalartos tegulaneus* is considered threatened because of its limited numbers in the wild, small area of distribution, and continuing destruction of its natural habitat.

Encephalartos transvenosus Stapf & Burtt Davy 1926

PLATES 35, 342, 343

Encephalartos transvenosus, the epithet derived from *trans,* Latin and meaning the other side, and *venosus,* prominently veined, referring to the prominent veins on the underside of the leaflets, is called Modjadji cycad and Modjadji palm. **Stems** arborescent, solitary, erect, sometimes branched as a result of injury, often suckering from the base to form clumps, exceptional plants to 13 m (42 ft) tall but average plants with stems to 5–8 m (16–26 ft) tall, 40–65 cm (16–26 in) in diameter, crown containing a considerable amount of brown wool. **Leaves** numerous, straight or gently arching, dark green, 1.5–2.5 m (4.9–8.2 ft) long, 20–40 cm (8–16 in) wide, flat, emergent leaves very hairy but soon glabrous. Petiole 20–40 cm (8–16 in) long, 1.8 cm (0.7 in) in diameter. Rachis distinctly yellowish. Basal leaflets gradually reduced in size until finally forming several prickles, median leaflets 10–20 cm (4–8 in) long, 2–4.5 cm (0.8–1.8 in) wide, inserted at more or less right angles to the rachis, deflexed, straight or slightly falcate, crowded and overlapping in an upward direction, both margins with one to five teeth. **Female cones** one to five, more or less ovoid, 50–80 cm (20–32 in) long, 20–30 cm (8–12 in) in diameter, golden brown and slightly woolly. Peduncle short, cone appearing sessile. Median sporophylls about 8 cm (3.2 in) long. Sporophyll face somewhat wrinkled or nearly smooth, 3–4 cm (1.2–1.6 in) high, 6–7 cm (2.4–2.8 in) wide, with a beaklike projection about 2.5 cm (1 in) long. Sarcotesta red to orange-red when ripe. Sclerotesta subcylindrical to ovoid, 29–33 mm (1.1–1.3 in) long, 19–24 mm (0.8–0.9 in) in diameter, brown, with 10–17 slightly raised longitudinal ridges. **Male cones** one to four, subcylindrical, 30–60 cm (12–24 in) long, 13–15 cm (5.1–6 in) in diameter, golden brown, rounded at the apex. Peduncle 2.5–3 cm (1–1.2 in) long, 5–5.5 cm (2–2.2 in) in diameter, usually hidden among the cataphylls, the cone appearing sessile. Median sporophylls about 4.5 cm (1.8 in) long. Sporophyll face 1.5 cm (0.6 in) high, 3.5 cm (1.4 in) wide, projecting into a beak 1–1.5 cm (0.4–0.6 in) long. Sporangia in a single patch with a sterile notch at the front and rear. **Habitat:** *Encephalartos transvenosus* grows as an almost pure forest formation at Modjadji Kraal, at elevations of 600–1000 m (2000–3300 ft). Rainfall is 600–1500 mm (24–59 in) annually, falling in summer. The area is a mist belt where the summers are cool and humid and there is no frost in winter. **Distribution:** South Africa, Northern province, in the Soutpansberg and Letaba and Duiwelskloof districts, the largest concentration in the self-governing state of Lebowa at Modjadji Kraal.

Encephalartos transvenosus was probably first seen about 1650 by the Balobedu Baga Modjadji tribe shortly after they migrated south across the Limpopo River into what is now the Duiwelskloof area of the Northern province (formerly Transvaal), South Africa. The Modjadji rain queens came to know and respect these cycads and have protected them since. Without the protection of these tribal leaders, it is doubtful that this remarkable stand of cycads would have endured.

The botanical world was made aware of *Encephalartos transvenosus* in 1926 when Otto Stapf and Joseph Burtt Davy described it in *A Manual of the Flowering Plants and Ferns of the Transvaal with Swaziland.* John Hutchinson and George Rattray (1933) decided that *E. transvenosus* did not warrant species status and placed it into synonymy under *E. altensteinii.* Then, Murray Ross Henderson (1945) once again elevated *E. transvenosus* to the rank of species, where it has properly remained.

Encephalartos transvenosus is better known as the Modjadji cycad or Modjadji palm and is without doubt the best known of the South African species of the genus. Not only is it the most majestic *Encephalartos,* but anyone who has had the good fortune to see this cycad as an almost pure forest with thousands of huge specimens will never forget the experience. I believe it is the most impressive stand of cycads anywhere on earth. The reason for this magnificent display is that the rain queens of the Lovedu have protected them for many generations. In fact, damaged stems are the exception, and then the damage has usually been caused by lightning or strong winds. The maximum height for this species is about 13 m (42 ft) though most of the larger plants in the forest are 6–10 m (20–33 ft) tall.

Great quantities of fertile seed are produced almost every year, and regeneration in habitat is good. As many as four female cones are produced on a plant, each weighing as much as 34 kg (75 pounds). The cones take almost 18 months to mature, and it is not unusual to see two sets of cones on the same plant. Seed will stay viable as long as 3 years, and I have seen it germinating on flat rocks in full sun after a light rain.

Encephalartos transvenosus is not only beautiful but does extremely well in cultivation. It has a rapid growth rate, and 4- to 5-year-old seedlings will have many leaves as much as 1 m (3.3 ft) long. It is reasonably cold tolerant and very adaptable as far as growing conditions are concerned. It does, however, require considerable space to develop to its full potential. Leaf growth will soon demand a space 4–5 m (13–16 ft) in diameter. Care should also be exercised that the leaves do not overhang traffic areas as the leaflets are stiff and spiny, definitely not gardener friendly!

In 1983 the rain queen established the Modjadji Nature Preserve on 305 hectares (754 acres) to protect the 10,000–15,000 mature cycads growing there. Because of the high degree of regeneration and the number of plants in habitat, *Encephalartos transvenosus* is not considered threatened. There are two other areas where *E. transvenosus* is protected, the Lekgagameetse and Mphaphuli Reserves. The cycads are fewer and the colonies less prolific there than at the Modjadji Reserve. The Lebowa government has established a cycad nursery that makes possible the legalized and controlled sale of specimens to the public at reasonable prices. Since its inception, this nursery has produced many thousands of plants for distribution and represents one of the most successful conservation efforts in southern Africa.

Encephalartos trispinosus (W. J. Hooker) R. A. Dyer 1965a

PLATES 344, 345

Encephalartos horridus var. *trispinosa* W. J. Hooker 1863

The epithet for *Encephalartos trispinosus* is derived from *tri-,* Latin for three, and *spinosus,* spiny, referring to typical median leaflets, which have two marginal spines and a terminal spine. **Stems** arborescent, erect, freely suckering from the base to form a clump, to about 1 m (3.3 ft) tall, 25–30 cm (10–12 in) in diameter, larger stems often leaning to one side and becoming curved. **Leaves** numerous, spreading, greenish gray to blue, curved backward and downward, often twisted toward the apex, 0.7–1.4 m (2.3–4.6 ft) long, 15–27 cm (6–11 in) wide, emergent leaves glabrous or nearly so. Petiole 12–25 cm (4.7–10 in) long, 15–17 mm (0.6–0.7 in) in diameter. Leaflets sometimes overlapping in the upper half and in a V formation, reduced in size and becoming simple toward the base, median leaflets often curved upward, 10–18 cm (4–7.1 in) long, 1.5–2.5 cm (0.6–1 in) wide, apex pungent, lower margin with one or two pungent and sometimes twisted lobes 1–3 cm (0.4–1.2 in) long. **Female cones** solitary, barrel shaped, 40–50 cm (16–20 in) long, 16–18 cm (6.3–7.1 in) in diameter, yellow or yellowish green, with a conical apex. Peduncle about 4 cm (1.6 in) long and 6 cm (2.4 in) in diameter, stout. Median sporophylls 7–9 cm (2.8–3.5 in) long. Sporophyll face 3.5 cm (1.4 in) high, 6–7 cm (2.4–2.8 in) wide, the face protruding 2.5–3 cm (1–1.2 in), its surface pimpled and deeply wrinkled. Sarcotesta reddish orange to yellowish orange when ripe. Sclerotesta subovoid, 26–31 mm (1–1.2 in) long, 17–21 mm (0.7–0.8 in) in diameter, light tan, with 7–12 indistinct longitudinal grooves. **Male cones** solitary, rarely two, erect, subcylindrical, 25–35 cm (10–14 in) long, 6.5–8 cm (2.6–3.2 in) in diameter, narrowed toward both ends, yellow or yellowish green. Peduncle 5.5–7 cm (2.2–2.8 in) long, 2.5–3.5 cm (1–1.4 in) in diameter, glabrous, furrowed. Median sporophylls 2.5–3 cm (1–1.2 in) long. Sporophyll face 7–10 mm (0.3–0.4 in) high, 19–25 mm (0.8–1 in) wide, projected into a beak about 7 mm (0.3 in) long. Sporangia in a single irregularly shaped patch. **Habitat:** Dry coastal scrub and along cliffs above rivers, into flat land at relatively low elevations, in association with *Aloe, Euphorbia,* and *Protea.* Rainfall is 625–725 mm (25–29 in) annually, falling mainly in summer. **Distribution:** South Africa, Eastern Cape province, Albany, Alexandria, and Bathurst districts, in the catchment areas of the Bushmans and Great Fish Rivers.

Encephalartos trispinosus was first described as a variety of *E. horridus* by William Jackson Hooker in 1863. Subsequently, it was considered as a variant of either *E. horridus* or *E. lehmannii* by some and finally recognized as a separate species in 1965 by Robert Allen Dyer. The reason it took so long for *E. trispinosus* to be described as a species is the great variability in its leaf characteristics. Leaflets range from closely spaced with large, spine-tipped lobes, to closely spaced with small lobes, to widely spaced with occasional spines, or sometimes to lacking lobes or spines altogether. The one feature tying all these variants together is their greenish yellow cones. Without cones, positive identification of *E. trispinosus* is sometimes impossible.

Encephalartos trispinosus is most closely related to *E. horridus* and, more distantly, to *E. lehmannii* and *E. princeps.* None of these species overlap in distribution, and no hybrids or intergrades are known. Without cones, *E. trispinosus* can be separated from *E. horridus* by close examination of the leaflets. This will usually disclose the fact that in *E. trispinosus* the upper side of the leaflet is flat or slightly cupped whereas in *E. horridus* the upper surface is rounded and the margins are somewhat revolute.

Hybridization has been noted between *Encephalartos trispinosus* and *E. altensteinii,* and there are possible hybrids between *E. trispinosus* and *E. arenarius.* I have seen many apparently second-generation segregates of *E. trispinosus* and *E. altensteinii* hybrids. Mendel's principle is clearly seen in these populations, which show individuals midway between the species involved, and other plants with characteristics more like those of one of the parents.

Encephalartos trispinosus, because of its fairly wide range and large populations, is quite common in cultivation. It can be found in many botanical gardens, parks, and private collections. Hardy to several degrees of frost and easy to grow, it is no wonder that it is well represented in gardens. Horticultural requirements are only two, well-drained soil and a sunny location. *Encephalartos trispinosus* is reasonably fast growing and will produce at least one growth cycle per year, sometimes two. It responds well to applications of fertilizer during spring and summer, which greatly increase its rate of growth. Owing to its relatively short leaves, it is easy to fit into smaller areas or gardens. The striking bluish gray leaves, with their long spines and tips curved backward and downward, make this cycad very decorative. Under proper conditions, as many as four sets of leaves may be retained in good condition. It is interesting to note that fresh leaves display the very silvery color associated with this species, but each year more of this waxy coating is lost until the leaves are completely dull green. Because of its hardiness, ease of cultivation, and beauty, this cycad is highly recommended.

Encephalartos trispinosus is still reasonably common in the wild, but the large numbers of plants in gardens and collections testify to the wholesale removal of this species from its habitat in the past. The World Conservation Union (IUCN) has classified *E. trispinosus* as vulnerable, that is, facing a high risk of extinction in the wild (Walter and Gillett 1998). The South African Police and nature conservation officers have curtailed illegal collection and sale of this cycad in more recent years. In the long term, it will take the cooperation of all collectors and dealers to make the existing laws work.

Encephalartos turneri Lavranos & D. L. Goode 1985

PLATES 346, 347

Encephalartos turneri is named in honor of Ian S. Turner of Zimbabwe, a student of cycads who provided specimens and field notes for the description of this species. **Stems** arborescent, erect though larger stems frequently decumbent, suckering from the base to form clumps, to 3 m (10 ft) tall and 80 cm (32 in) in diameter, covered by irregularly spaced leaf scars. Cataphylls narrowly ovate acuminate, densely white to gray tomentose on the underside. **Leaves** numerous, straight, to 1.5 m (4.9 ft) long and 37 cm (15 in) wide. Rachis round in cross section, 2 cm (0.8 in) in diameter near the base, sparsely whitish tomentose in the lower third, glossy dark green, becoming yellowish with age. Leaflets inserted about 2.5 cm (1 in) apart toward the base, reduced to prickles in the basal section, more crowded and becoming overlapping toward the apex, median leaflets to 20 cm (8 in) long and 3 cm (1.2 in) wide, somewhat boat shaped, terminating in a single, sharp, hooklike point curved backward and downward, glabrous, margins of the leaflets in the upper half of the leaf entire, in the lower half usually with none to three prickles on the upper margin, none or one prickle on the lower, near the leaflet base. **Female cones** one to three, more or less ovoid, about 28 cm (11 in) long and 14 cm (5.5 in) in diameter, yellowish with a pink bloom, glabrous. Peduncle about 5 cm (2 in) long. Median sporophylls about 6 cm (2.4 in) long. Sporophyll face 3.5 cm (1.4 in) high, 7 cm (2.8 in) wide, in fresh material, with lateral ridges extending into the marginal lobes, glabrous, wrinkled above and below, the terminal facet rhomboid, 10 mm (0.4 in) high, 12–14 mm (0.5–0.6 in) wide, slightly concave. Sarcotesta scarlet when ripe. Sclerotesta 32–35 mm (1.3–1.4 in) long, 19–23 mm (0.7–0.9 in) wide, tan, the surface more or less smooth with 13–14 indistinct ridges. Chalaza 11–15 mm (0.4–0.6 in) long, 10–12 mm (0.4–0.5 in) wide. **Male cones** one to three, subcylindrical, about 30 cm (12 in) long and 8.5 cm (3.4 in) in diameter at the midpoint, slightly tapering toward both ends, yellowish with a pink bloom, glabrous. Peduncle about 12 cm (4.7 in) long and 22 mm (0.9 in) in diameter. Median sporophylls about 3 cm (1.2 in) long, almost at right angles to the axis. Sporophyll face glabrous, about 15 mm (0.6 in) high and 25 mm (1 in) wide, the terminal facet rhomboid, 7 mm (0.3 in) high, 11 mm (0.4 in) wide, slightly concave. Sporangia in a single heart-shaped patch. **Habitat:** Low granite hills in semishade or full sun, usually among boulders. Rainfall averages 800–1000 mm (32–39 in) annually, falling almost entirely during the hot summer. **Distribution:** Mozambique, Nampula province, about 22 km (14 miles) southeast of Nampula.

Encephalartos turneri is distinctive if not unique among other species of East Africa in several characteristics. The yellow-pink cones are not found in any other species of the genus with the exception of *E. sclavoi* from the western Usambara Mountains in Tanzania. Besides cone color, *E. sclavoi* bears some resemblance to *E. turneri* in the boat-shaped leaflets and the slightly hooked terminus of the leaflets. The sclerotesta of the seed, however, differs markedly in size, shape, and surface texture from that of *E. turneri.* Even with these similarities, the widely disjunct distribution of these two cycads makes a close relationship questionable. All the species growing near the range of *E. turneri* are quite distinct from it. The *E. manikensis* complex has green cones, and *E. ferox* and *E. gratus* have orange-red cones.

Encephalartos turneri is relatively rare in collections, therefore not a great deal is known about its adaptability as a garden or conservatory plant. It is very handsome and no doubt would be more widely grown as propagation material is made available. In 1997 a large quantity of seed was collected and distributed worldwide. This will increase the number of this cycad in cultivation and make its conservation status more secure. It is hoped that future botanical expeditions will add to our knowledge of this species.

The conservation status of *Encephalartos turneri* is not well known. In 1997 I was informed that a "large" colony of *E. turneri* had been discovered, though the total number of plants was not mentioned. We must consider its status unknown but probably threatened.

Encephalartos umbeluziensis R. A. Dyer 1951

PLATES 348, 349

The epithet for *Encephalartos umbeluziensis* refers to the Mbuluzi (Umbeluzi) River in southern Mozambique, along which this cycad grows. **Stems** subterranean with thick, tuberous, contractile roots, rarely branching unless damaged, to about 30 cm (12 in) long and 25 cm (10 in) in diameter, covered with persistent leaf bases, crown densely brown woolly. **Leaves** two to five or more, slightly arching and spreading in shade, straight and upright in sun, glossy dark green, 1–2 m (3.3–6.6 ft) long, 40–60 cm (16–24 in) wide, flat, emergent leaves tomentose except for the inner surface of the leaflets, soon becoming glabrous. Petiole slender, 5–10 cm (2–3.9 in) long, 7–12 mm (0.3–0.5 in) in diameter toward the base, unarmed, base densely woolly. Rachis more or less round and not grooved on the upper surface. Leaflets reduced in size toward the apex and base but basal leaflets not reduced to prickles, median leaflets linear, 10–30 cm (4–12 in) long, 8–15 mm (0.3–0.6 in) wide, flatly inserted into the rachis but then slightly twisted so that the upper surface is directed more or less toward the leaf apex, margins entire or with none or one spine on the upper margin, one to three spines on the lower. **Female cones** one to four, more or less cylindrical, 25–30 cm (10–12 in) long, 12–15 cm (4.7–6 in) in diameter, olive green to yellowish green when mature. Peduncle 10–15 cm (4–6 in) long, 3–3.5 cm (1.2–1.4 in) in diameter. Sporophyll face smooth and flattened, glabrous, 3–3.5 cm (1.2–1.4 in) high, 5–6.5 cm (2–2.6 in) wide, the terminal facet rhomboid, about 13 mm (0.5 in) high and 20 mm (0.8 in) wide. Sarcotesta yellow to light brown when ripe. Sclerotesta 25–33 mm (1–1.3 in) long, 17 mm (0.7 in) in diameter, dull light tan, evenly covered with irregular fissures breaking the surface into small islands and with about 12 evenly spaced longitudinal ridges. Chalaza pitlike, about 3 mm high and 5 mm (0.2 in) wide. **Male cones** one to four, subcylindrical, 25–35 cm (10–14 in) long, 6–8 cm (2.4–3.2 in) in diameter, tapering slightly toward the apex, olive green to yellowish green. Peduncle 10–17 cm (4–6.7 in) long, 2–3 cm (0.8–1.2 in) in diameter, orange-green. Sporophyll face flattened, 10–13 mm (0.4–0.5 in) high, 17–20 mm (0.7–0.8 in) wide, only slightly projecting, the lower edge with lobes or teeth, the facets usually distinct. Sporangia in a single patch with a sterile border and a prominent notch at the outside edge. **Habitat:** Flat, hot, dry deciduous thorn forest, at elevations generally less than 120 m (400 ft). Rainfall averages 625–750 mm (25–30 in) annually, falling mainly in summer. Summers are hot and generally humid, winters mild and frost-free. **Distribution:** Mozambique and Swaziland, in the catchment area of the Mbuluzi (Umbeluzi) River.

In 1924 an undescribed cycad was discovered growing in a garden in Inhambane, Mozambique. As time passed, additional specimens were found growing in gardens both in Mozambique and Swaziland. It was not until 1945 that a cycad enthusiast, Brandsby A. Key, discovered wild plants on the banks of the Mbuluzi (Umbeluzi) River about 30 km (18 miles) from Maputo, Mozambique. He collected plants and cone and leaf specimens that were shown to Robert Allen Dyer and Inez Clare Verdoorn at the Botanical Research Institute, Pretoria, South Africa. After several years of fieldwork, Dyer described *Encephalartos umbeluziensis* in 1951. During completion of the manuscript for this book, I was informed that research into the type of *E. striatus* Stapf & Burtt Davy (1926) indicates that it may be the same as *E. umbeluziensis.* If this proves to be correct, the name *E. striatus* will have priority.

Encephalartos umbeluziensis is similar to *E. aplanatus* and *E. villosus* in its underground stem and long leaves but differs from those species in a number of features. The habitats are entirely different, *E. umbeluziensis* growing in flat, dry, hot forests, and *E. aplanatus* and *E. villosus* favoring relatively tall forests that are generally cool and moist. Mature cones of *E. umbeluziensis* are green or yellowish green, those of *E. aplanatus* and *E. villosus* golden yellow. In *E. umbeluziensis* the leaves are upright, dark green, petiolate, and the lower leaflets are not reduced to prickles. In *E. aplanatus* and *E. villosus* the leaves are arching, light green, sessile, and the lower leaflets are reduced to prickles all the way to the base. Even though *E. umbeluziensis* and *E. aplanatus* both occur in northeastern Swaziland, no actual overlapping of distribution has been recorded, and no intermediate plants are known. *Encephalartos umbeluziensis* has been crossed with *E. villosus* and the resultant offspring, as might be expected, are midway between the parents. I am not aware of any other natural or artificial crosses involving *E. umbeluziensis.*

Because of its remote location, restricted range, and scattered occurrence, large numbers of *Encephalartos umbeluziensis* have not been introduced into cultivation. It is infrequent in collections, either public or private. In cultivation, *E. umbeluziensis* is undemanding and of relatively rapid growth. In my 25 years of experience growing *E. umbeluziensis,* contrary to what I have read, it has proved to be somewhat frost tolerant, with no apparent foliar damage following temperatures well below freezing. It is also more sun tolerant than *E. villosus,* but it is best to protect plants from hot afternoon sun to prevent leaf burn. The smaller size of *E. umbeluziensis,* its upright habit, and glossy dark green leaves make it a fine garden plant.

The remoteness and difficult terrain of its habitat have protected *Encephalartos umbeluziensis* from overcollecting until more recent years. New roads into the area have permitted access to the habitat, allowing plants to be more easily collected. This continuing drain on a limited population requires that this species be considered endangered.

Encephalartos villosus Lemaire 1867b

PLATES 350, 351

The epithet for *Encephalartos villosus* is Latin for hairy, referring to the densely woolly crown and juvenile leaves. **Stems** mainly subterranean, more or less globose, rarely as much as 15 cm (6 in) above ground in mature plants, 20–30 cm (8–12 in) in diameter, commonly suckering from the sides of the stem to form the typical multiheaded clumps seen in older specimens, crown densely woolly, roots numerous, thick, tuberous, and contractile. Cataphylls densely tomentose, about 63 mm (2.5 in) long and 25 mm (1 in) wide. **Leaves** usually 3–10, upright, then arching, light to medium glossy green, 1.5–3 m (4.9–10 ft) long, 40–50 cm (16–20 in) wide, flat, emergent foliage densely white tomentose. Petiole lacking or rarely 5–6.5 cm (2–2.6 in) long, 1.9 cm (0.8 in) in diameter. Leaflets 20–25 cm (8–10 in) long, 1–2 cm (0.4–0.8 in) wide, lanceolate, falcate, margins with none to several spines, basal leaflets gradually reduced in length toward the leaf base and ending in a series of prickles. **Female cones** one to four, barrel shaped, 40–50 cm (16–20 in) long, 16–20 cm (6.3–8 in) in diameter, bright yellow to apricot yellow when ripe. Peduncle 75–138 mm (3–5.4 in) long, 38–63 mm (1.5–2.5 in) in diameter. Sporophylls with a serrated lower edge that overlaps the sporophyll beneath it. Sporophyll face 40–63 mm (1.6–2.5 in) high, 31–55 mm (1.3–2.2 in) wide. Sarcotesta scarlet when ripe. Sclerotesta flattened long ovoid, 28–31 mm (1.1–1.2 in) long, 14–17 mm (0.6–0.7 in) in diameter, with 9–12 prominent longitudinal ridges, the surface between the ridges with a network of numerous, shallow, indistinct grooves. Chalaza prominent, slightly bent to one side, about 5 mm (0.2 in) in diameter, perforated with several pits. **Male cones** one to four, long conical, 50–60 cm (20–24 in) long, 8–10 cm (3.2–4 in) in diameter, pale yellow to yellow-green when ripe, emitting a strong odor when dehiscing. Peduncle 6–16 cm (2.4–6.3 in) long, 25–55 mm (1–2.2 in) in diameter. Sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 10–14 mm (0.4–0.6 in) high, 25–34 mm (1–1.3 in) wide. Sporangia in a single patch, covering the entire lower surface of the sporophyll except for a narrow sterile border. **Habitat:** Subtropical coastal belt in low forest to more or less temperate areas with mild winters, from near sea level to about 300 m (1000 ft). Rainfall averages 1000–1250 mm (39–49 in) annually, falling mostly in summer. **Distribution:** South Africa, Eastern Cape province, from near East London eastward through the Transkei, through KwaZulu-Natal province, into the southeastern portion of Mpumalanga province, and from there into Swaziland.

Encephalartos villosus is one of the most abundant cycads in South Africa, and within its distributional area it is very popular as a garden plant. It is one of the few species of *Encephalartos* that generally prefers a shady habitat. Although it will grow relatively well in full sun, it performs better in a shaded location by producing longer, broader leaves of a brighter green. Over its extensive range, *E. villosus* exhibits considerable variation in leaflet length and width and the number of marginal spines. Eastern Cape specimens have shorter, heavily spined leaflets whereas those from the northern limits of the cycad's range have longer leaflets that are nearly spineless. I have seen a very distinctive specimen from near Paddock in western KwaZulu-Natal that has extremely narrow leaflets with numerous long marginal spines.

The closest relatives of *Encephalartos villosus* are *E. aplanatus* of Swaziland and *E. umbeluziensis* of Mozambique. *Encephalartos aplanatus* may be distinguished from *E. villosus* by its longer leaves, to 3.5 m (11.5 ft) rather than 3 m (10 ft), often with a short petiole, and its larger leaflets, to 30 × 4 cm (12 × 1.6 in) rather than 25 × 2 cm (8 × 0.8 in), with margins more toothed and undulate than flat. *Encephalartos umbeluziensis* may be distinguished from *E. villosus* by its dark green leaves, leaflets with fewer marginal spines, and most distinctively, its lower leaflets not reduced to spines, giving the leaf a relatively long unarmed petiole.

Natural hybrids between *Encephalartos villosus* and *E. lebomboensis* are frequent in the Pongola Poort area. Hybrids have also been noted with *E. altensteinii* in the western part of its range, notably in the East London area. Artificial hybrids have been produced with *E. trispinosus* and *E. umbeluziensis.*

Encephalartos villosus is an undemanding plant in cultivation and for this reason has been popular for many years. It does very well in the garden or as a container plant. As already mentioned, it prefers light overhead cover for best growth. Soil with a substantial amount of organic material seems best suited for its growth. *Encephalartos villosus* is not ideal for every garden, however, because of its size.

Even though *Encephalartos villosus* is very abundant in its habitat, it is subject to the same pressures as other, less common species. Considerable amounts of its habitat have been lost to agriculture and land clearance, and a large number of plants have been removed for cultivation in more recent years. Even so, this species is still in a strong position to survive and may be considered as not threatened.

Encephalartos whitelockii P. J. H. Hurter 1995

PLATES 352, 353

Encephalartos successibus Vorster & Heibloem 1995b

The epithet for *Encephalartos whitelockii* recognizes Loran M. Whitelock for his work on cycads and for assisting Johan Hurter's exploration in central Africa. Stems arborescent, often suckering from the base to form clumps, to 3.5 m (11.5 ft) long, rarely as long as 4.2 m (14 ft), 35–40 cm (14–16 in) in diameter, old leaf bases persisting on the crown. Leaves numerous in a dense crown, rigid, upright, medium green, 3.1–3.4 m (10–11 ft) long, rarely as long as 4.1 m (14 ft), 45–62 cm (18–24 in) wide, generally flat to slightly keeled, sometimes curved slightly backward and downward at the apex, emergent leaves light green and lightly white to tan tomentose, glabrous when mature. Petiole glabrous, swollen at the base, 13–16 cm (5.1–6.3 in) long, 5–5.5 cm (2–2.2 in) in diameter. Leaflets toothed, angled forward about 30°, spreading, opposing leaflets at an angle of about 160° to each other, thus almost in the same plane, not overlapping, basal leaflets gradually reduced to spines, median leaflets 23–30 cm (9.1–12 in) long, 2–2.8 cm (0.8–1.1 in) wide, narrowly elliptical and falcate, gradually acuminate toward the apex, the apex somewhat directed toward the leaf apex, margin flat, armed with spines every 2–7 cm (0.8–2.8 in). Female cones generally one to three, produced in succession, erect, ovoid, 30–45 cm (12–18 in) long, 15–19 cm (6–7.5 in) in diameter, green, turning yellow at maturity. Peduncle 10–22.5 cm (4–9 in) long, 5.5–6 cm (2.2–2.4 in) in diameter, generally hidden by the cataphylls, the cone appearing sessile. Median sporophylls descending, 5.5–6.5 cm (2.2–2.6 in) long, the facets generally smooth, with two lateral facets and a narrow wedge-shaped median facet. Sporophyll face 3–4.5 cm (1.2–1.8 in) high, 4.5–7 cm (1.8–2.8 in) wide. Sarcotesta orange-red to deep red when ripe. Sclerotesta ellipsoidal to ovoid, 31–38 mm (1.2–1.5 in) long, 22–25 mm (0.9–1 in) in diameter, smooth except for 11–17 indistinct longitudinal ridges. Chalaza prominent, 9–13 mm (0.4–0.5 in) long, 8–10 mm (0.3–0.4 in) wide, with large pits. Male cones usually four to eight, produced in succession, pendulous, narrowly ovoid, 30–50 cm (12–20 in) long, 9–10 cm (3.5–4 in) in diameter, green, turning yellow at maturity. Peduncle 32–50 cm (13–20 in) long, 3–4 cm (1.2–1.6 in) in diameter. Sporophylls 32–41 mm (1.3–1.6 in) long, spreading. Sporophyll face rhombic, 14–17 mm (0.6–0.7 in) high, 29–33 mm (1.1–1.3 in) wide, median sporophylls with two distinct lateral facets and a median facet, the terminal facet flat or slightly concave. Sporangia in a single patch with a deep sterile notch at both front and rear margins. Habitat: Cliffs or steep rocky hillsides in riverine forest at an elevation of about 1200 m (3900 ft). Distribution: Uganda, Mapanga River Falls, 2 km (1.2 miles) west of Lake George.

In its early history, *Encephalartos whitelockii,* informally referred to as the Lake George or Mapanga River Falls cycad, was assigned to several other species of central African *Encephalartos.* David Prain (1917), William J. Eggeling (1940), and Walter Robyns (1948) felt that the Mapanga River Falls cycad was an extension of the range of *E. laurentianus,* which occurs some 1700 km (1060 miles) to the southwest along the Kwango River, which in turn forms a portion of the border between the Democratic

Republic of the Congo (Zaire) and Angola. Ronald Melville (1957) included the Mapanga River Falls cycad in his broad concept of *E. hildebrandtii.* Denis Heenan (1977) observed that the Mapanga River plants are intermediate between *E. hildebrandtii* and *E. laurentianus* but felt they should be included under the latter name. More recently, Paul Bamps and Stanislaw Lisowski (1990) felt that the closest relationships of the Mapanga River Falls cycad might be with their newly described species from Zaire, *E. ituriensis.*

In the early 1990s, several botanical expeditions into central Africa resulted in the collection of a complete series of cone and leaf specimens of the Mapanga River Falls cycad. Examination of this material disclosed that it was an undescribed species. Two researchers described it independently under two different names, *E. whitelockii* and *E. successibus*; the name *E. whitelockii* was published first and therefore has priority.

The closest relatives of *Encephalartos whitelockii* appear to be *E. equatorialis, E. ituriensis,* and *E. laurentianus. Encephalartos whitelockii* differs from *E. equatorialis* in its smooth rather than wrinkled facets of the exposed megasporophylls, its leaflets, not overlapping or only slightly so rather than strongly overlapping, and its lack of a concentration of three or four teeth near the base of the upper leaflet margin. It differs from *E. ituriensis* in its ovoid rather than shortly cylindrical female cone and its hard and rigid leaflets rather than soft-textured, flexible leaflets. It differs from *E. laurentianus* mainly in its smaller leaflets, 23–30 × 2–2.8 cm (9.1–12 × 0.8–1.1 in) rather than 45–50 × 4.5–5 cm (18–20 × 1.8–2 in), which are hard and rigid rather than thin, soft, and flexible, and its megasporophylls, which are smooth and green rather than wrinkled and reddish brown.

In cultivation, *Encephalartos whitelockii* is fast growing and trouble-free. Insect infestations are unusual, and when they do occur they are easily controlled. This cycad has unexpected cold tolerance, and there has been no apparent damage to mature leaves following exposure to several degrees of frost. When grown in the Northern Hemisphere, however, *E. whitelockii* often produces new leaves in the winter, and these can be damaged during periods of frost. The main drawback in growing this species is its large size, and an area approximately 7.5 m (25 ft) in diameter must be provided for its full development. Even so, the overall effect of *E. whitelockii* in the landscape, with its stiff, slightly arching leaves, is arresting.

The conservation status of *Encephalartos whitelockii* seems quite secure. Although it is only known from a single population around the Mapanga River Falls, there are unconfirmed reports of other populations farther along the Mapanga River. The known population, composed of thousands of adult plants, is healthy and vigorous. Seedling regeneration is prolific, with thousands of seedlings and small plants in evidence. For these reasons, *E. whitelockii* can be considered as not threatened.

Encephalartos woodii Sander 1908

PAGES 2–3, PLATES 354, 355

Encephalartos woodii is named in honor of John Medley Wood (1827–1915), curator of the Natal Botanic Gardens, later the Durban Botanic Gardens, who discovered the original and only specimen of this cycad in 1895. **Stems** arborescent, erect, usually solitary but suckering from the base, or in cultivation sometimes branching at the crown, to 6 m (20 ft) tall and 75 cm (30 in) in diameter, with the expanded base in large plants reaching a diameter of 1 m (3.3 ft), crown persistently woolly. **Leaves** numerous, 2–3 m (6.5–10 ft) long, 40–50 cm (16–20 in) wide, slightly arching, spreading, heavily tomentose at emergence, the tomentum soon shed. Petiole rounded above and angled below, 16–17 cm (6.3–6.7 in) long, 22–26 mm (0.9–1 in) in diameter. Leaflets reduced to prickles toward the base, median leaflets of juvenile leaves bright glossy green, 18–23 cm (7.1–9.1 in) long, 5 cm (2 in) wide at the widest part, the upper margin near its base forming a lobe with three to five spines 1–2 cm (0.4–0.8 in) long with an additional one or two spines along the margin midway to the apical spine, the lower margin usually with one to three smaller spines, median leaflets of adults unequally drawn out, the upper margin making a broad curve toward the apex whereas the lower more or less straight, angled upward, and overlapping in an upward direction, margins entire and with no apical spine in mature leaves. **Female cones** not described. **Male cones** usually 1–8, rarely as many as 21, cylindrical, 40–90 cm (16–36 in) long, 15–20 cm (6–8 in) in diameter, bright orange-yellow. Peduncle 25–30 cm (10–12 in) long, 8 cm (3.2 in) in diameter, at first erect, then leaning to the side while the cone stays more or less perpendicular, thereby moving the cones laterally out of the center of the crown and allowing them more space to develop. Sporophylls 7.5–8.5 cm (3–3.3 in) long, apex drawn out into a beak 3.5–4.5 cm (1.4–1.8 in) long. Sporophyll face 2 cm (0.8 in) high, 3–5 cm (1.2–2 in) wide, the terminal facet 5–15 mm (0.2–0.6 in) high, 10–15 mm (0.4–0.6 in) wide. Sporangia in a single patch with a sterile notch at the front and surrounded by a sterile border 2–3 mm wide. **Habitat:** One plant, on a steep, south-facing slope on the margin of a forest. **Distribution:** Historically, South Africa, KwaZulu-Natal province, Mtunzini district, Ngoye Forest.

Encephalartos woodii is one of the rarest cycads and is now considered extinct in the wild. John Medley Wood found a single male clump of this species in 1895. The estimated total number of propagations from the original wild plant is about 11, consisting of 7 offsets and 4 large stems removed between 1903 and 1916. The last remaining stem, removed from its habitat on May 29, 1916, is described in a letter of that date from the acting district forester at Ngoye, South Africa:

> Forester Prior has now consigned the only known plant of this species in the Ngoye to the Chief: Division of Botany, Pretoria . . . the weight of this plant is between 13 and 15 hundred pounds [590–680 kg] and is about 12 feet [3.7 m] long and 18 inches [46 cm] in diameter.

This type of operation by today's conservation standards would probably cause an outcry from organizations and individuals all over the world. Had the original clump not been removed from the wild, however, the cycad would in all probability now be extinct, rather than extinct in the wild. *Encephalartos woodii* has done so well in cultivation that it is estimated that there may be approximately 500 plants growing in various botanical gardens and private collections all over the world. Since many of these plants are now well-established adults, producing offsets, there could be several hundred more in existence within a very few years—all from the humble beginnings of 11 divisions from the original single plant.

Encephalartos woodii is probably the most sought after cycad, not only because of its rarity and notoriety but also its beauty. The combination of vigorous growth and an umbrella-shaped canopy of long, glossy green, arching leaves makes it one of the most majestic cycads.

Barring the unlikely discovery of a female plant of *Encephalartos woodii* in the wild or a sex change in one of the existing cultivated plants, the only means of propagation is by offsets. In my experience, it takes 10 or more years for reestablished plants to produce offsets. Once the process starts, however, the plants are generally quite prolific in their production, and two to four offsets may be produced each year.

There are two other avenues being explored in the hope of mass producing *Encephalartos woodii.* The first is by tissue culture, which has been moderately successful with one or two other cycads. The main problem with tissue culture is that clean tissue, that is, tissue without bacterial or fungal contamination, should be used. In an old plant like *E. woodii,* which could be several thousand years old, a multitude of infections can have taken place over its lifetime, so sterile tissue is virtually an impossibility. In more recent years, propagation of plants by the use of leaf cuttings (Dalzell 2002, Osborne and Dalzell 1996) has been successful. In this procedure a leaf is detached from the parent plant, the cut end treated with fungicide and rooting hormone, then the cutting is planted in a humidity chamber in sterile mix (such as sponge rock) over bottom heat. Eventually, callous tissue is formed, and from this callus, root differentiation takes place. After the development of a root system, there is the possibility of bud initiation and the development of a plant. The propagation of plants from leaf cuttings, however, is a slow process that is not always successful. I feel confident that additional experimentation with available growth regulators and hormones will eventually provide a more reliable procedure.

One other option is to cross *Encephalartos woodii* with its closest relative, *E. natalensis,* which has already been done, producing a hybrid generation that is 50% *E. woodii.* When these seedlings mature, a female can be fertilized with *E. woodii* pollen, producing offspring that will be about 75% *E. woodii.* Theoretically, within five generations a 97% pure *E. woodii* population could be produced. The main problem is continuity, as the whole process would take 75 years or more to complete!

In 1965, while visiting Ernest Thorp, curator of the Durban Botanic Gardens, I was taken to the Old Fort Garden to see a plant that closely resembled *Encephalartos woodii.* It appeared to be a somewhat smaller edition of the *E. woodii* plants from the original collection. At the time I thought it was only a specimen of *E. woodii* that was stressed from growing in too much shade. Roy Osborne et al. (1995) described five plants closely resembling *E. woodii* that had apparently originated in the Krantzkloof Nature Reserve, in Kloof, KwaZulu-Natal. One of these five plants is a plant at the Old Fort Garden in Durban. These five plants resemble *E. woodii* more than *E. natalensis.* Their cones, sadly all males, are indistinguishable from those of the original *E. woodii.* Their leaves are more like those of *E. woodii* than *E. natalensis,* being long and arching with glossy green and forwardly lobed leaflets. These plants present an enigma that will no doubt take considerable research before a definite conclusion can be reached as to their taxonomic position.

Lepidozamia Regel 1857

Encephalartos sect. *Lepidozamia* (Regel) Miquel 1863, *Macrozamia* sect. *Lepidozamia* (Regel) Miquel 1868
Catakidozamia W. Hill 1865
Macrozamia sect. *Monoorientales* J. Schuster 1932

The name *Lepidozamia* is derived from *lepidos,* Greek for scaly and referring to the scalelike leaf bases and cataphylls clothing the stem, and *Zamia.* Two species (type, *L. peroffskyana*). Chromosome number $2n = 18$. *Lepidozamia* together with most of the other cycad genera constitute the family Zamiaceae.

Stems arborescent, generally unbranched except as a result of injury, tall, one species (*L. hopei*) the tallest known existing cycad, attaining a height of as much as 17.5 m (57.4 ft), the persistent leaf bases and cataphylls forming an alternating pattern on mature stems.

Leaves long, arching, glossy, dark to medium green, unarmed, the leaflets attached at the upper midpoint of the rachis and lacking callous bases, falcate and drooping toward the apex, entire, slightly reduced toward the base and apex but never reduced to spines at the base.

Female cones solitary, ovoid, erect, subsessile, covered with short brown tomentum. Sporophyll face deflexed with the apex often upturned, without a sharp spine as in *Macrozamia.* Seeds large, usually two on each sporophyll, rarely three and the third usually inserted between and somewhat higher than the other two.

Male cones solitary, elliptical, subsessile, erect until the pollen is shed, then rapidly decumbent, densely light brown tomentose over the entire exterior surface.

Habitat: Wet sclerophyll forest or rain forest, from sea level to about 615 m (2000 ft).

Distribution: Australia, coastal tropical and subtropical Queensland, and northern coastal New South Wales.

Both species of the genus *Lepidozamia* are handsome, hardy to semihardy plants with several attributes recommending them for landscape or garden use. Foremost in

Lepidozamia peroffskyana

this respect are their rapid growth, graceful habit, and complete lack of spines or teeth anywhere on the plants. Both species of *Lepidozamia* are listed in Appendix II of CITES.

Lepidozamia hopei (W. Hill) Regel 1876a

PLATES 356, 357

Catakidozamia hopei W. Hill 1865, *Macrozamia hopei* (W. Hill) F. M. Bailey 1886, *M. denisonii* var. *hopei* (W. Hill) J. Schuster 1932

Lepidozamia hopei is named in honor of Louis Hope (1817–1894), known in Australia as the father of the Queensland sugar industry. **Stems** solitary or sometimes with numerous branches as a result of injury, to 17.5 m (57.4 ft) tall and 1.6 m (5.2 ft) in diameter at the base, younger portions exhibiting the scars of old leaf bases, older portions developing a smooth light-colored skin. **Leaves** numerous, at first suberect, then spreading and later drooping, on adult plants 2–3 m (6.5–10 ft) long, 40–80 cm (16–32 in) wide, glossy dark green, pubescent when young but glabrescent with age. Petiole 30–60 cm (12–24 in) long, 3–4 cm (1.2–1.6 in) in diameter, angled above, rounded to angular below, base swollen and shortly tomentose. Leaflets in 80–100 pairs, flat, spreading but curved backward and downward, and drooping, toward the apex, basal leaflets reduced in length but not very short and never reduced to spines, median leaflets broadly strap shaped, 20–40 cm (8–16 in) long, 1.5–3 cm (0.6–1.2 in) wide, margin entire, tapered to an acute apex, slightly constricted at the base but without a callus. **Female cones** solitary, ovoid, 40–80 cm (16–32 in) long, 20–30 cm (8–12 in) in diameter, somewhat narrowed at the base, gray-green. Peduncle short, cone appearing sessile. Sporophylls 5–8 cm (2–3.2 in) long. Sporophyll face 2.5 cm (1 in) high, 3.5–6.5 cm (1.4–2.6 in) wide, lightly brown tomentose, with thin and warty edges, deflexed but the apex often turned up. Sarcotesta bright red when ripe. Sclerotesta 4–6 cm (1.6–2.4 in) long, 2.5–3.5 cm (1–1.4 in) in diameter, medium brown, the surface with numerous indistinct longitudinal grooves and a network of shallow irregular grooves. **Male cones** solitary, more or less cylindrical, 40–70 cm (16–28 in) long, 10–15 cm (4–6 in) in diameter. Peduncle short, cone appearing sessile. Sporophyll face broadly wedge shaped, 4–6 cm (1.6–2.4 in) high, 6–8 cm (2.4–3.2 in) wide, brown tomentose, usually abruptly curved backward and downward, with an upcurved apex. Sporangia covering the entire undersurface without a sterile notch at the apex. **Habitat:** Wet tropical rain forest, usually in hilly areas, from sea level to about 1000 m (3300 ft). Rainfall averages 1700–2500 mm (67–98 in) annually, falling mainly in summer. Temperatures range from a summer high of 33°C (91°F) to a winter low of 5°C (41°F), with frosts very rare. **Distribution:** Australia, northeastern Queensland, lowland coastal forests and the Atherton Tableland, from the Daintree River near Cooktown in the north to as far south as the Rockingham Bay region near Ingham.

In 1865 Walter Hill described *Catakidozamia* based on collections from tropical eastern Australia. Although Eduard August von Regel made the combination *Lepidozamia hopei* in 1876, he thought the genus was from Mexico. In 1886 Frederick Manson Bailey placed the species in *Macrozamia,* and finally in 1959, Lawrence A. S. Johnson, in *The Families of Cycads and the Zamiaceae of Australia,* returned the species to *Lepidozamia* where it rightly belongs.

Lepidozamia hopei has been referred to as the tallest cycad in the world with a trunk height sometimes in excess of 17 m (56 ft). It is truly a remarkable plant when its white stem and crown of dark green leaves reach above the forest canopy. It is common but scattered within its range in the northern Queensland rain forest. Growing in the same general area as *L. hopei* is a small, fernlike cycad, *Bowenia spectabilis.*

In cultivation, *Lepidozamia hopei* grows well from seed, and rapidly if given sufficient heat and moisture. Although this is a cycad of the wet Tropics, it does very well in temperate climates. There are fine specimens growing in the Royal Botanic Gardens, Sydney, where winter temperatures can be quite cold. In my garden in southern California, *L. hopei* is routinely exposed to several degrees of frost each winter without experiencing leaf burn or other adverse effects. *Lepidozamia hopei* grows very slowly in temperate climates, however, and does not appear to have the landscape potential of *L. peroffskyana.* But it is a handsome cycad, with its glossy dark green leaves and wide leaflets, and these attributes make it a worthwhile garden plant. As true of *L. peroffskyana, L. hopei* lacks spines or teeth and can be used in pedestrian traffic areas.

The conservation status of *Lepidozamia hopei* appears to be very secure. It is reasonably common over a large geographical area, much of which is natural rain forest. Seed production in its habitat is sporadic, but seedling regeneration is good and the species seems to be in no danger. It is one of the few cycads that can be considered as not threatened.

Lepidozamia peroffskyana Regel 1857

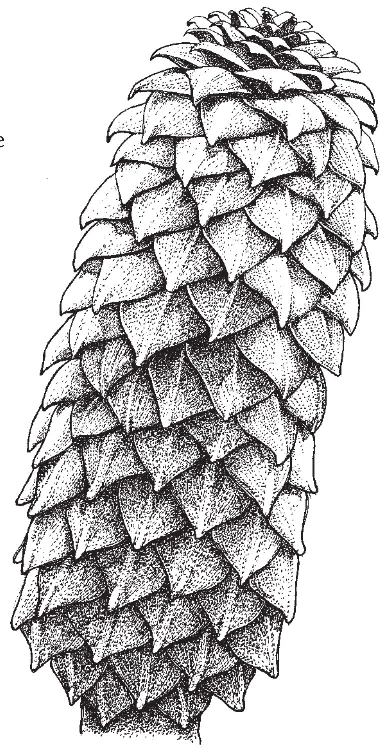
PAGE 244, PLATES 358–360

Macrozamia peroffskyana (Regel) Miquel 1868

Macrozamia denisonii C. Moore & F. Mueller 1858, *Encephalartos denisonii* (C. Moore & F. Mueller) F. Mueller 1859, *Lepidozamia denisonii* (C. Moore & F. Mueller) Regel 1876a

Lepidozamia peroffskyana is named in honor of Leo Alexejewitsch Perowski (1792–1856), mineralogist and chief administrator of the St. Petersburg botanical garden where the type plant was grown. **Stems** arborescent, erect, solitary but sometimes branched as a result of injury, to 7 m (23 ft) tall, 30–60 cm (12–24 in) in diameter, usually armored with large persistent leaf bases of light tan, all parts shortly pubescent when young but glabrescent with age. Cataphylls abundant, alternating with the successive crowns of leaves. **Leaves** as many as 150 in a crown, not twisted but gracefully arching, 2–3 m (6.5–10 ft) long, 40–55 cm (16–22 in) wide, emerging leaves a distinctive bronze that soon changes to a glossy dark green. Petiole 30–60 cm (12–24 in) long, angled above, rounded to angular beneath, unarmed, base swollen and covered with a dense light brown tomentum. Leaflets in 75–125 pairs, inserted along the upper midline of the rachis, falcate, curved backward and downward, slightly narrowed but not callous at the base, drooping toward the tip, median leaflets 10–30 cm (4–12 in) long, 7–13 mm (0.3–0.5 in) wide, with 7–13 scarcely raised veins on the underside, margin entire. **Female cones** solitary, erect, ovoid, 40–90 cm (16–36 in) long, 25–35 cm (10–14 in) in diameter. Peduncle 1.5–2 cm (0.6–0.8 in) long, 3–3.5 cm (1.2–1.4 in) in diameter, but the cone appearing sessile. Sporophylls usually with two ovules, rarely three, median sporophylls 5–8 cm (2–3.2 in) long. Sporophyll face 2–3 cm (0.8–1.2 in) high, 4–8 cm (1.6–3.2 in) wide, deflexed but the apical tips sometimes turned upward, the interior parts of the cone bright salmon red. Sarcotesta red when ripe, rarely yellow. Sclerotesta 43–60 mm (1.7–2.4 in) long, 28–33 mm (1.1–1.3 in) in diameter, light tan, appearing smooth but with 6–10 indistinct longitudinal ridges and a network of very shallow grooves. Chalaza 15–20 mm (0.6–0.8 in) long, 15–18 mm (0.6–0.7 in) wide, containing numerous pits. **Male cones** solitary, subsessile, erect until the pollen is shed, subcylindrical, 40–75 cm (16–30 in) long, 10–12 cm (4–4.7 in) in diameter, interior parts of the cone more or less cream colored. Sporophylls 6–8 cm (2.4–3.2 in) long. Sporophyll face 1–1.5 cm (0.4–0.6 in) high, 2.5–3.5 cm (1–1.4 in) wide, apex short triangular or abruptly curved backward and downward but the tip often upturned. Sporangia covering the entire undersurface of the sporophyll without a sterile notch at the tip. **Habitat:** Wet sclerophyll forest, sometimes bordering on rain forest in hilly country, usually under thick forest cover, from near sea level to about 1000 m (3300 ft). Rainfall is 1700–2000 mm (67–79 in) annually, falling mainly in summer and fall. Temperatures range from summer highs above 32°C (90°F) to winter lows of 2°C (36°F). **Distribution:** Australia, from Taree, northern coastal New South Wales in the south, to Nambour, southern coastal Queensland, in the north.

When the genus *Lepidozamia* and its type species *L. peroffskyana* were named by the Russian botanist Eduard August von Regel in 1857, the description was based on a plant of unknown origin (at one time thought to be from Mexico), growing in the St. Petersburg botanical garden. Regel based his description on material without cones and maintained the genus later in 1876 when he had knowledge of the cones. When the origin of *Lepidozamia* was found to be Australian it was soon (except by Regel himself) placed in the genus *Macrozamia. Lepidozamia* differs from *Macrozamia* in its nearly sessile cones, the radically different sporophyll face, which is densely covered with a fine tomentum and that lacks the characteristic terminal spine of *Macrozamia,* the insertion of the falcate leaflets into the upper midline of the rachis, and the



Lepidozamia female cone

leaflets' lack of a callous base. Using these criteria, *Lepidozamia* can be easily distinguished from *Macrozamia.*

Lepidozamia peroffskyana is popular in botanical gardens for its rapid growth rate, large size, glossy foliage, and arching leaves. This cycad, like *L. hopei,* is one of the very few that is gardener friendly as a result of its complete lack of spines or teeth. Additionally, the leaves and leaflets are very flexible and not easily damaged by foot traffic or strong winds. In cultivation, growth is rapid, and large specimens of *L. peroffskyana* can be produced in relatively few years. This is an undemanding cycad that seems to adapt well to various soil, water, and light conditions. Several degrees of frost will not damage the leaves, and though it normally grows in shaded conditions in its habitat, it will generally not show leaf damage if grown in full sun. As true of some other cycads, this species may look better in cultivation than it does in its natural habitat. The reason for this is the continuous availability of water and nutrients, which enhance leaf color and promote more robust growth.

Lepidozamia peroffskyana produces very large female cones, and average cones may weigh as much as 30 kg (66 pounds) and contain as many as 360 seeds. The large seeds are easily germinated but take several months before showing signs of life. Heat can speed the process but only after the seed has gone through its maturing period of about 6 months while the embryo develops.

Lepidozamia peroffskyana is relatively common over its extensive range, and seedling regeneration is prolific. For these reasons this species is not considered threatened.

Macrozamia Miquel 1842

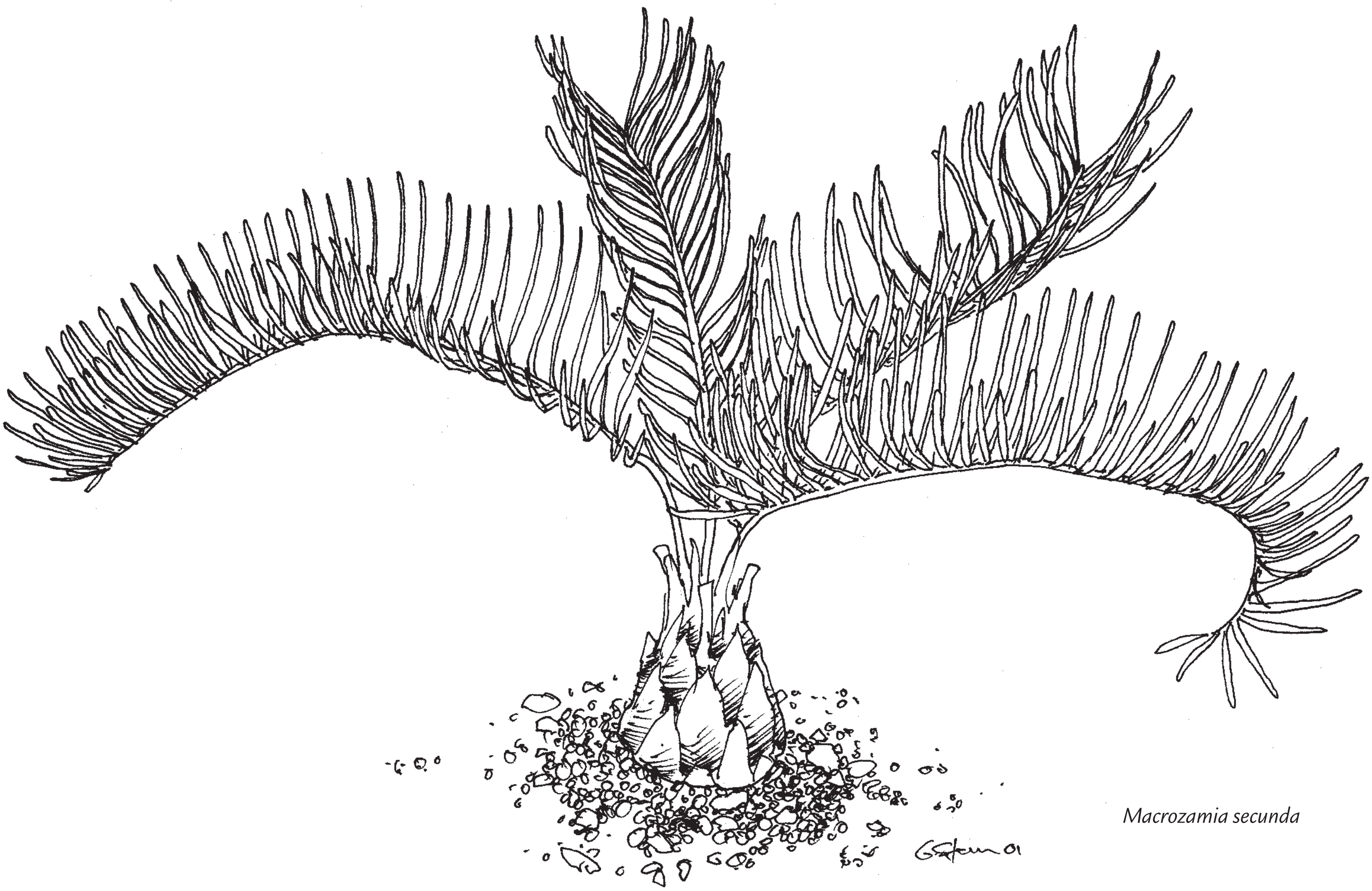
The name *Macrozamia* is derived from *macros,* Greek for large, and *Zamia.* Thirty-eight species (type, *M. riedlei*) with several more to be described. Chromosome number $2n = 18$. *Macrozamia* together with most of the other cycad genera constitute the family Zamiaceae. *Macrozamia* is divided into two sections: *Macrozamia,* large cycads, and *Parazamia,* dwarf cycads.

Stems usually subterranean except for some species of section *Macrozamia* that produce arborescent stems to a maximum height of 9 m (29 ft), the longer stems often decumbent rather than upright.

Leaves varying considerably in size and color from one species to another, those of section *Macrozamia* as long as 3 m (10 ft) and are either flat or keeled and not twisted, those of section *Parazamia* short and often erect and twisted. Leaf color varies from light green through dark green to blue-gray. Leaflets range from narrow, approximately 3 mm in *M. parcifolia,* to broad, as much as 2 cm (0.8 in) in *M. fawcettii,* and may be flat or channeled. The leaves of juvenile plants may differ considerably from those of the adults, the usual differences being the toothed leaflet apex and the long slender petiole of juvenile to subadult plants.

Female cones ranging widely in size and number, those of section *Parazamia* usually small and solitary, those of section *Macrozamia* large and numbering as many as eight. Cone color various shades of green to glaucous green. Sporophyll face armed with an erect, sharp, stiff spine, those at the bottom of the cone short, sometimes almost absent in some species, increasing in size toward the cone apex. Sarcotesta color yellow to bright red, rarely both colors in the same species with yellow and red seeds produced on adjacent plants.

Male cones displaying the same variation as the female cones in size and number, those of section *Parazamia* usually small and solitary, those of section *Macrozamia* much larger and numbering as many as 100 (*M. moorei*). Cone color either green or glaucous green. Terminal spine on each sporophyll fine and sharp, in section *Parazamia* sometimes only a rudimentary spine on the lower sporophylls and only enlarging to about 2 mm long at the cone apex.



Macrozamia secunda

Habitat: There is a wide range of variation in *Macrozamia* habitats. The plants are found from the margins of rain forest (*M. johnsonii*) to dry desert (*M. macdonnellii*), from sea level (*M. communis*) to 1500 m (4900 ft; *M. stenomera*). Generally, all grow under cover of *Eucalyptus* forest. Only those species from the central Australian desert and Western Australia commonly grow in open situations. Rainfall varies, with those in Western Australia and the Northern Territory receiving very little precipitation, to those of rain forest margins in Queensland receiving much precipitation. Temperatures range from 49°C (120°F) in desert areas to lows of –4°C (25°F) at some of the higher elevations in winter. *Macrozamia stenomera* is generally subjected to snowfall each winter.

Distribution: Australia, mainly coastal New South Wales and Queensland, with some species extending into the mountains and interior plains, also the Northern Territory, Alice Springs area (*Macrozamia macdonnellii*), and southwestern Western Australia (*M. dyeri, M. fraseri, M. riedlei*).

In 1959, Lawrence A. S. Johnson of the National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, published a revision of the Zamiaceae of Australia. In it two species of *Macrozamia* were returned to the genus *Lepidozamia,* three species were newly described (*M. communis, M. lucida, M. stenomera*), one taxon was elevated to the rank of species from variety (*M. diplomera*), and *M. pauli-guilielmi* was separated into subspecies (all three subsequently raised to species). Johnson's revision untangled the taxonomic confusion within the genus *Macrozamia* that was brought about by several earlier botanists who did not have the benefit of as much knowledge of the plants, foremost among whom was Julius Schuster, working in Germany. Johnson's revision was so well researched that it laid a firm foundation for all future taxonomic work.

The Australian genus *Macrozamia* is separated into two sections. Section *Macrozamia* consists of all the larger growing species such as *M. douglasii, M. moorei,* and *M. riedlei,* section *Parazamia* of all the dwarf species that generally have subterranean stems such as *M. fawcettii, M. lomandroides,* and *M. pauli-guilielmi.* Section *Macrozamia* has three disjunct areas of distribution, the eastern coast, central Australia, and the southwestern coast, whereas section *Parazamia* is only found on the eastern coast.

More recent field studies by David L. Jones of the Australian National Botanic Gardens, Canberra, have necessitated some departures from Johnson's classification. These studies have brought to light several new species in section *Parazamia,* raised *Macrozamia pauli-guilielmi* subspecies *flexuosa* and *plurinervia* to species, and recognized *M. douglasii* and *M. mountperriensis* as distinct instead of as synonyms of *M. miquelii.* Also, the disjunct population in New South Wales has been shown to be different from *M. moorei* of Queensland and has been described as a separate species, *M. johnsonii.*

The interest in Australian cycads has focused a great deal of attention on their habitats and distribution, and several more species may be described. This new interest in cycads is also slowly changing the Australians' thinking of them as noxious "weeds." They are now all considered by the Australian government as endangered and have been afforded the protection they deserve. Cycads are still being destroyed in some areas, however, in an attempt to protect domestic animals from poisoning. It is hoped that the growing awareness of the historical and botanical value of these plants will provide the needed stimulus for change.

The conservation status of the macrozamias ranges from not threatened to extremely endangered though all species of *Macrozamia* are listed in Appendix II of CITES. Some species have a wide distribution coupled with large populations and prolific regeneration, whereas others are very restricted in range and are having their remaining habitats cleared for agriculture. The interest in Australian cycads has caused a growing demand for plants, both in Australia and abroad. Collecting of wild plants would ultimately have a devastating effect on the populations of the rarer species. Some growers are starting to produce nursery plants from seed, and it is hoped that this will reduce the numbers of plants removed from habitat.

Macrozamia cardiacensis P. I. Forster & D. L. Jones in Hill et al. 1998

The epithet for *Macrozamia cardiacensis* refers to this cycad's type locality, Cardiac Hill, Queensland, Australia. **Stems** subterranean or less commonly arborescent, to 40 cm (16 in) long, and 20–40 cm (8–16 in) in diameter. **Leaves** usually 10–20, very glossy deep green, 1.5–2 m (4.9–6.6 ft) long, flat, not twisted. Petiole 30–40 cm (12–16 in) long, 1.3–2 cm (0.5–0.8 in) in diameter at the lowest leaflets. Leaflets in 50–70 pairs, basal leaflets reduced to spines on only two-thirds of the petiole length, median leaflets decidedly lighter in color below, 23–31 cm (9.1–12 in) long, 9–11 mm (0.4–0.5 in) wide, armed with an apical spine, the callous base pale yellow, margin flat and entire. **Female cones** solitary, narrowly ovoid, 32–36 cm (13–14 in) long, 11–14 cm (4.3–5.5 in) in diameter.

Sporophyll face 2.5 cm (1 in) high, 4.5 cm (1.8 in) wide, apical spine 7–48 mm (0.3–1.9 in) long, longest at the cone apex. Sarcotesta orange-red when ripe. Sclerotesta oblong, 22–35 mm (0.9–1.4 in) long, 12–20 mm (0.5–0.8 in) in diameter, light brown, with 10–12 shallow, indistinct, longitudinal grooves. Chalaza 5–6 mm (0.2 in) in diameter, slightly projecting. **Male cones** solitary, spindle shaped, 35–40 cm (14–16 in) long, 6.5–8 cm (2.6–3.2 in) in diameter. Sporophylls 22–32 mm (0.9–1.3 in) long, 10–15 mm (0.4–0.6 in) wide, apical spine 2–30 mm (to 1.2 in) long, longest at the cone apex. **Habitat:** Steep slopes with open forest of *Eucalyptus.* **Distribution:** Australia, southeastern Queensland, Mount Walsh National Park.

Macrozamia cardiacensis has been separated from the *M. miquelii* complex relatively recently. It is distinguished from *M. miquelii* by its large size, darker green leaves with leaflets reduced to spines on only two-thirds of the petiole length, and larger female and male cones. It is also closely related to *M. douglasii* from which it differs by its pale yellow rather than white callous leaflet base, its basal leaflets more widely spaced, 20–28 mm (0.8–1.1 in), and its greater number of spinelike leaflets on the petiole, usually 18–30.

I am not aware of any specimens of *Macrozamia cardiacensis* in cultivation. Some seed has become available, and this species will no doubt be cultivated. I foresee no problems in growing *M. cardiacensis,* as its requirements should be similar to those of *M. miquelii.* The handsome appearance of *M. cardiacensis* should insure its use as a garden plant.

The conservation status of *Macrozamia cardiacensis* is good with two large colonies known from Mount Walsh National Park in southeastern Queensland. Where it occurs, *M. cardiacensis* is very common, and regeneration is prolific. For these reasons it is not considered threatened.

Macrozamia communis L. A. S. Johnson 1959

PLATE 361–363

Macrozamia communis, the epithet Latin for common, referring to the abundance of this cycad in its coastal habitats, is called burrawong. **Stems** usually subterranean but in shallow soils forming an aerial stem 1–2 m (3.3–6.6 ft) tall, 30–60 cm (12–24 in) in diameter. Cataphylls stiff and spinelike, 10–16 cm (3.9–6.3 in) long, 5–10 mm (0.2–0.4 in) wide at the base. **Leaves** 50–100 in a crown, erect at first, then spreading, gracefully arched, 0.7–2 m (2.3–6.6 ft) long, and about 45 cm (18 in) wide. Petiole flattened above and rounded below, 12–40 cm (4.7–16 in) long, 8–18 mm (0.3–0.7 in) wide at the lowest leaflets. Rachis not twisted and more or less flattened, with two narrow lateral grooves decurrent from the base of the leaflets. Leaflets in 70–130 pairs, spreading and somewhat drooping, angled forward acutely, upper leaflets crowded but the lowest ones often 3–6 cm (1.2–2.4 in) apart, lower leaflets reduced and spinelike, median leaflets leathery but flexible, straight, linear, dull dark green, 16–35 cm (6.3–14 in) long, 4–12 mm (to 0.5 in) wide, tapered to a pungent apex, markedly narrowed at the base, with a whitish or cream anterior callus at the attachment, margins flat and entire. **Female cones** one to six, erect at first, drooping when mature, cylindrical, 20–45 cm (8–18 in) long, 10–20 cm (4–8 in) in diameter, glaucous green, inner parts of the cone salmon pink when mature. Peduncle 8–30 cm (3.2–12 in) long, 2–3.5 cm (0.8–1.4 in) in diameter. Sporophyll face 15–43 mm (0.6–1.7 in) high, 30–85 mm (1.2–3.3 in) wide, glaucous, with a single flattened erect spine, shortest 1–2.5 cm (0.4–1 in) long at the base, longest 4–8 cm (1.6–3.2 in) long at the apex, 8–20 mm (0.3–0.8 in) wide at its base. Sarcotesta vermilion red when ripe, rarely yellow. Sclerotesta ovoid to globular, 30–35 mm (1.2–1.4 in) long, 22–25 mm (0.9–1 in) in diameter, smooth. **Male cones** 1–10, erect, drooping after pollen is shed, cylindrical, 20–45 cm (8–18 in) long, 8–12 cm (3.2–4.7 in) in diameter, glaucous green. Peduncle 10–15 cm (4–6 in) long, 3 cm (1.2 in) in diameter, furrowed, glaucous green. Sporophyll face 1.5–2.5 cm (0.6–1 in) high, 2–4 cm (0.8–1.6 in) wide, glaucous green, with a single upturned, flattened spine 1–50 mm (to 2 in) long, longest at the cone apex. Sporangia in a single patch. **Habitat:** Flat areas in coastal deep sands under open *Eucalyptus* forest, from slightly above sea level to about 300 m (1000 ft), sometimes forming dense stands where it is the dominant understory plant. Rainfall averages 1000–1500 mm (39–59 in) annually, evenly distributed throughout the year. Temperatures range from a summer maximum of 35°C (95°F) to a winter minimum of −4°C (25°F). **Distribution:** Australia, New South Wales, generally in coastal areas from the Macleay River system in the north, to Bega in the south.

For many years *Macrozamia communis* was known by the misapplied names *M. corallipes* and *M. spiralis.* It was later found that *M. corallipes* is in fact a synonym of *M. spiralis.* When Lawrence A. S. Johnson (1959) revised the macrozamias, his research disclosed that this cycad was in fact undescribed. As it was the most common cycad in New South Wales, Johnson named it *M. communis.*

The only species that might be confused with *Macrozamia communis* are *M. douglasii, M. lucida,* and *M. miquelii.*

It can be distinguished from those species by its large, dull dark green leaves, spine-free petiole at least 12 cm (4.7 in) long, and seeds averaging more than 3.5 cm (1.4 in) long.

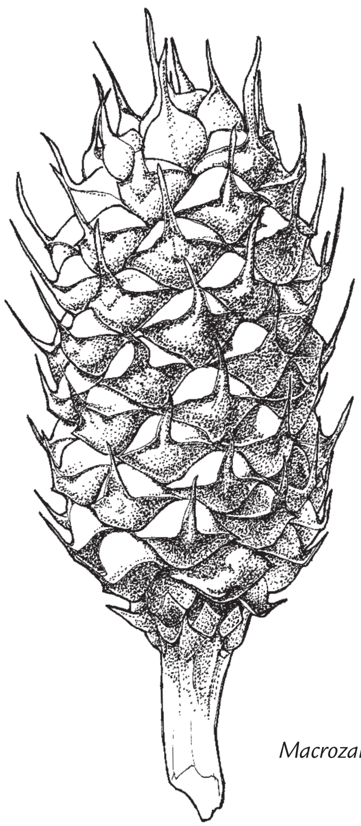
Macrozamia communis is probably the best known and most widely cultivated cycad native to Australia, doubtless because of the great numbers that occur in habitat and their ease of transplanting and cultivation. Because it is one of the most common Australian cycads, it has been involved in many incidents of stock poisoning. In some areas of its range it occurs in dense stands consisting of thousands of plants. Regeneration is very good and the seedlings are relatively fast growing. *Macrozamia communis* has contractile roots that pull the stem into soft soils, leaving only the crown of leaves and cones exposed. This growth habit protects the plants from damage during the annual grassfires that occur in most of its growing areas.

In cultivation, *Macrozamia communis* does exceedingly well. It has a moderate rate of growth and if given sufficient water and fertilizer will form sizable specimens in a reasonably short time. For best results, *M. communis* must have well-drained soil. In its habitat it seems to prefer partially shaded locations and usually grows under open *Eucalyptus* forest. Some cultivated plants placed in lawn areas in full sun seem to adjust to this condition without any apparent problems, possibly because of year-round watering. The leaves are gracefully arching and quite handsome with the contrast of the dark green of the leaflets against the cream-colored callus at their base. *Macrozamia communis* will take several degrees of frost without apparent damage. This cycad should be more commonly used in landscapes because of its beauty and ease of cultivation.

The only major insect problem of *Macrozamia communis* is mealybugs. Because of the way new leaves are produced, one after another rather than all in a single flush, these insects have a chance to multiply and damage emerging leaves. This problem can be easily corrected by the application of any good insecticide about twice during the growing season. Scale insects may sometimes infest the crown and can be treated in the same way. Grasshoppers seem to be the only chewing insect that commonly attacks the foliage of *M. communis.* This cycad is strongly recommended to anyone starting a collection of cycads because of its ease of cultivation and hardiness. Because of the large populations of *M. communis* in habitat, and the copious regeneration shown by them, this species is not considered vulnerable.

Macrozamia concinna D. L. Jones in Hill et al. 1998

The epithet for *Macrozamia concinna* is derived from *concinnus,* Latin for neat, pretty, or elegant, referring to this cycad's habit. **Stems** subterranean, 8–15 cm (3.2–6 in) in diameter. **Leaves** usually one to five in a crown, semiglossy, deep green above and lighter below, 50–90 cm (20–36 in) long, strongly to moderately keeled. Petiole 9–24 cm (3.5–9.4 in) long, 4–7 mm (to 0.3 in) in diameter at the lowest leaflets. Rachis strongly spirally twisted. Leaflets in 40–60 pairs, basal leaflets not reduced to spines, median leaflets 14–21 cm (5.5–8.3 in) long, 4–6 mm (0.2 in) wide, apex without a spine, margins flat or curved slightly inward, entire. **Female cones** solitary, ovoid, 13–15 cm (5.1–6 in) long, 7–8 cm (2.8–3.2 in) in diameter. Sporophyll face 1–1.5 cm (0.4–0.6 in) high, 4–4.5 cm (1.6–1.8 in) wide, apical spine 2–30 mm (to 1.2 in) long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta ovoid, 21–26 mm (0.8–1 in) long, 18–24 mm (0.7–0.9 in) in diameter, tan, smooth. **Male cones** solitary, spindle shaped, 14–22 cm (5.5–8.7 in) long, 4–4.5 cm (1.6–1.8 in) in diameter. Sporophylls 16–20 mm (0.6–0.8 in) long, 14–17 mm (0.6–0.7 in) wide, apical spine to 13 mm (to 0.5 in) long, longest at the cone apex. **Habitat:** Dry sclerophyll woodland in hilly areas. **Distribution:** Australia, New South Wales, upper Hunter Valley, northward to the hills and ranges around Liverpool Plains.



Macrozamia female cone

In 1995 Kenneth D. Hill and I investigated a colony of what would be known as *Macrozamia concinna* near Hanging Rock Lookout, New South Wales. The plants were scattered under *Eucalyptus* woodland and were difficult to see when growing among clumps of grass. It is a dainty little plant that would be easy to overlook if one were not searching for it. It has stiff, strongly spirally twisted leaves, with long, more or less terete petioles. The leaflets are also stiff, dark green, and have inrolled margins.

To my knowledge, *Macrozamia concinna* is not commonly cultivated. Since it has been described, it will no doubt experience some pressure from collectors. Its size makes it a fine plant for both growing in pots and use in rock gardens. I would expect this cycad to adapt well to cultivation and exhibit good frost tolerance.

The conservation status of *Macrozamia concinna* seems secure. It has a widespread and sporadic distribution that will help protect it from collectors. Its small size and habit of growing among clumps of grass also makes *M. concinna* difficult to find. It can be considered as not threatened.

Macrozamia conferta D. L. Jones & P. I. Forster in Forster & Jones 1994

PLATE 364

The epithet for *Macrozamia conferta* is derived from *confertus,* Latin for pressed closely together or crowded, referring to the closely spaced leaflets. **Stems** subterranean, somewhat ovoid, 15–30 cm (6–12 in) in diameter, branched stems not uncommon and some plants with as many as 12 crowns. **Leaves** usually one to five per crown, erect, 35–60 cm (14–24 in) long, shiny dark green, spirally twisted two to three times, emergent leaves somewhat tomentose but glabrous with age. Petiole dull dark green, the upper surface flat to slightly convex, the lower strongly convex, 7–21 cm (2.8–8.3 in) long, including the woolly expanded base, 7–12 mm (0.3–0.5 in) wide at the lowest leaflet. Leaflets in 45–80 pairs, linear, shiny bright green on both surfaces, with stomata only on the lower surface, 6–30 cm (2.4–12 in) long, longest at the center of the leaf, 2–6 mm (to 0.2 in) wide, angled forward 30–60°, obliquely erect, spaced 2–17 mm (to 0.7 in) apart, thick, upper surface concave in cross section, apex unevenly acuminate, the callous base greenish to greenish yellow, rarely reddish, margins entire and flat. **Female cones** solitary, erect, ovoid to ovoid cylindrical, 6–12 cm (2.4–4.7 in) long, 3.5–6 cm (1.4–2.4 in) in diameter, seeds ripening February–March. Peduncle elliptical in cross section, vertically furrowed, often twisted, 10–15 cm (4–6 in) long, 1–2 cm (0.4–0.8 in) in diameter, densely woolly. Sporophyll face transversely ovate to kidney shaped, 6–12 mm (0.2–0.5 in) high, 24–32 mm (0.9–1.3 in) wide, with a prominent depression just below the apical spine, apical spine to about 1 cm (0.4 in) long at the cone apex. Sarcotesta red when ripe. Sclerotesta irregularly globose, 19–23 mm (0.8–0.9 in) long, 19–21 mm (0.7–0.8 in) in diameter, the surface with numerous indistinct longitudinal grooves. **Male cones** solitary, erect at first, bending after pollen is shed, cylindrical, 7–18 cm (2.8–7.1 in) long, 2.5–4 cm (1–1.6 in) in diameter. Peduncle 4–18 cm (1.6–7.1 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, circular to elliptical in cross section. Sporophyll face narrowly cuneate to kidney shaped, 7–16 mm (0.3–0.6 in) high, 9–17 mm (0.4–0.7 in) wide, mostly with a vestigial spine but at the cone apex sometimes 12 mm (0.5 in) long. Sporangia in a single patch on sporophylls in the basal portion of the cone, in two patches on those in the apical portion. **Habitat:** Open *Eucalyptus* woodland at elevations of 600–750 m (2000–2500 ft), in flat to hilly areas with poor gray to white soils. **Distribution:** Australia, southern Queensland, Darling Downs district.

Macrozamia conferta belongs to section *Parazamia* and was said by David L. Jones and Paul I. Forster to be most closely related to *M. plurinervia* of northern New South Wales. It can be easily distinguished from *M. plurinervia* by its much narrower, shiny bright green, crowded leaflets and its smaller green cones and smaller seeds.

Apparently, Anthony R. Bean discovered *Macrozamia conferta* in 1987. I am not aware of any specimens in cultivation. It seems that all plants in section *Parazamia* do well in cultivation, so this species should be no exception. As true of other species in the section, *M. conferta* should be expected to be slow growing and cold tolerant. Because of its small size, it should prove to be an exceptional pot plant or equally useful in small rockery plantings.

Although *Macrozamia conferta* is locally common, it occupies a restricted range that is vulnerable to poaching. Collecting from the wild could lead to quick decimation of the cycad colonies if strict protection is not provided. For these reasons, *M. conferta* must be considered threatened.

Macrozamia cranei D. L. Jones & P. I. Forster in Forster & Jones 1994

PLATE 365

Macrozamia cranei is named in honor of Ralph Crane, an amateur botanist who first brought this cycad to the attention of David L. Jones and Paul I. Forster. **Stems** subterranean, unbranched, ovoid, 10–25 cm (4–10 in) in diameter. **Leaves** usually one to five, erect, glossy dark green, spirally twisted three to six times, 70–90 cm (28–35 in) long, emergent leaves tomentose, soon becoming glabrous, the leaflets glaucous. Petiole shiny dark green, the upper surface slightly convex, the lower strongly convex, 15–31 cm (6–12 in) long, 7–12 mm (0.3–0.5 in) wide at the lowest leaflet. Leaflets in 50–75 pairs, linear, dark glossy green above, dull glaucous green below, with stomata only on the lower surface, 7–30 cm (2.8–12 in) long, 2–7 mm (to 0.3 in) wide, angled forward about 50°, slightly twisted at the base, erect to widely spreading, the tips often drooping, moderately crowded, the upper surface slightly concave in cross section, apex unequally acuminate and yellow, the callous base inconspicuous, greenish to greenish white, rarely reddish, margin entire and flat. **Female cones** solitary, erect, ovoid, 8–13 cm (3.2–5.1 in) long, 4.5–5.5 cm (1.8–2.2 in) in diameter, green. Peduncle elliptical in cross section, vertically furrowed, 12–20 cm (4.7–8 in) long, 12–21 mm (0.5–0.8 in) in diameter. Sporophyll face transversely ovate, 1.5–2 cm (0.6–0.8 in) high, 2–4 cm (0.8–1.6 in) wide, with a prominent depression just below the apical spine, apical spine to about 15 mm (0.6 in) long at the cone apex. Sarcotesta orange to red when ripe. Sclerotesta ovoid, 2–2.5 cm (0.8–1 in) long, 1.5–2 cm (0.6–0.8 in) in diameter. **Male cones** solitary, erect, cylindrical, 8–22 cm (3.2–8.7 in) long, 2.5–5.5 cm (1–2.2 in) in diameter, green. Peduncle 8–22 cm (3.2–8.7 in) long, 13–20 mm (0.5–0.8 in) in diameter, elliptical to round in cross section. Sporophylls narrowly to broadly triangular, 13–20 mm (0.5–0.8 in) high, 15–20 mm (0.6–0.8 in) wide, apical spine almost lacking in lower two-thirds of the cone, to 1 cm (0.4 in) long in the upper third. Sporangia in a single patch on sporophylls in the basal portion of the cone, in two patches on those in the apical portion. **Habitat:** Open forest dominated by *Eucalyptus,* usually in shallow soils on limestone outcrops and generally on steep ridges, at elevations of 400–600 m (1300–2000 ft). **Distribution:** Australia, Queensland, Darling Downs district near the town of Texas.

Macrozamia cranei is a member of section *Parazamia* and is most closely related to *M. occidua* and *M. plurinervia.* It differs from *M. occidua* by its longer leaves, longer and shiny leaflets, and green cones, and from *M. plurinervia* by its leaves, which have a shiny dark green upper surface and dull glaucous lower surface, and its smaller green cones with smaller seeds.

Macrozamia cranei will no doubt be found to require the same horticultural conditions as *M. pauli-guilielmi.* The cycad will doubtless be slow growing and cold tolerant, same as the other species of section *Parazamia.*

The conservation status of *Macrozamia cranei* is not adequately known. Its overall range has not been established, nor has there been any estimate of its total number in the wild. Because of the lack of information and the limited numbers encountered thus far, it should be considered endangered until proven otherwise.

Macrozamia crassifolia P. I. Forster & D. L. Jones 1994

PLATE 366

The epithet for *Macrozamia crassifolia* is derived from *crassus,* Latin for thick, and *folium,* leaf, referring to the thick leaflets. **Stems** subterranean, more or less ovoid, 10–20 cm (4–8 in) in diameter, often branching and forming stems with as many as four crowns. **Leaves** usually one to five, erect, dark green, 0.5–1.1 m (1.6–3.6 ft) long in mature plants, spirally twisted one to four times. Petiole dull dark green, flat or slightly convex above, strongly convex below, 5–26 cm (2–10 in) long, 7–20 mm (0.3–0.8 in) wide at the lowest leaflets, the expanded base densely covered with thick brown tomentum. Leaflets in 52–86 pairs, narrowly linear, dull dark green above, the upper surface strongly concave in cross section, bright green below, not twisted, leathery, stomata only on the underside, 15–55 cm (6–22 in) long, longest at leaf midsection, becoming shorter toward the apex and base, 2–3.5 mm wide, angled forward about 45°, at first straight, then drooping in the apical third, the callous base white to greenish white, with white markings on the rachis between the leaflet bases, margin flat and entire. **Female cones** solitary, ovoid, 11–15 cm (4.3–6 in) long, 6–8 cm (2.4–3.2 in) in diameter, green, seeds ripening February–April. Peduncle 10–28 cm (4–11 in) long, 12–15 mm (0.5–0.6 in) in diameter, elliptical in cross section, vertically furrowed. Sporophyll face transversely elliptical to ovate, 12–15 mm (0.5–0.6 in) high, 25–35 mm (1–1.4 in) wide, with a prominent depression below the apical spine, apical spine to about 4 cm (1.6 in) long at the cone apex. Sarcotesta orange to red when ripe. Sclerotesta oblong to ovoid, 19–26 mm (0.8–1 in) long, 18–22 mm (0.7–0.9 in) in diameter, the surface smooth except for 10–12 indistinct and shallow longitudinal grooves. **Male cones** solitary, erect, more or less cylindrical, 10–16 cm (4–6.3 in) long, 3–4.5 cm (1.2–1.8 in) in diameter. Peduncle 10–16 cm (4–6.3 in) long, 10–14 mm (0.4–0.6 in) in diameter, elliptical in cross section. Sporophyll face broadly cuneate, 13–16 mm (0.5–0.6 in) high, 17–22 mm (0.7–0.9 in) wide, apical spine almost lacking in lower two-thirds of the cone, about 13 mm (0.5 in) long toward the apex. Sporangia in a single patch on sporophylls near the base of the cone, in two patches on those near the apex. **Habitat:** Steep slopes and dry streambeds among granite rocks and boulders under open forest dominated by *Eucalyptus,* at elevations of 340–420 m (1100–1400 ft). **Distribution:** Australia, southeastern Queensland, two small disjunct areas near Eidsvold and Mundubbera.

Macrozamia crassifolia is in section *Parazamia* and most closely related to *M. pauli-guilielmi,* from which it differs by its darker green, thicker leaflets, larger female cones, and male cones with prominent apical spines on the upper sporophylls. First collected in 1984 and thought to be a form of *M. pauli-guilielmi,* it was not identified as a new species until 1994 when Paul I. Forster and David L. Jones described it.

I am not aware of anyone who has cultivated this cycad, but I feel it would grow well by providing it the same conditions as those for *Macrozamia pauli-guilielmi.* As seed becomes available, as it surely must, the learning process will start about what this cycad requires for good growth.

The natural range of *Macrozamia crassifolia* is quite restricted but the cycad is locally common. If collecting could be limited to seed, no conservation problems should result. On the other hand, illegal poaching of plants from the wild could result in a real threat to the survival of this cycad. For these reasons, *M. crassifolia* must be considered vulnerable.

Macrozamia diplomera (F. Mueller) L. A. S. Johnson 1959

PLATES 367, 368

Encephalartos spiralis var. *diplomera* F. Mueller 1866, *Macrozamia spiralis* var. *diplomera* (F. Mueller) A. de Candolle 1868, *M. tridentata* f. *diplomera* (F. Mueller) J. Schuster 1932

The epithet for *Macrozamia diplomera* is derived from *diplo-,* Greek for doubled, and *meris,* part, referring to the common occurrence of divided leaflets in this cycad. **Stems** mostly subterranean, unbranched, globose to ovoid, 20–40 cm (8–16 in) in diameter. **Leaves** usually 5–50, straight, not twisted, stiff, dull green, 0.6–1.2 m (2–3.9 ft) long, 30 cm (12 in) wide, flat to slightly keeled. Petiole 10–30 cm (4–12 in) long, 8–20 mm (0.3–0.8 in) in diameter at the lowest leaflets, flattened above and rounded below. Rachis not twisted, more or less flattened, concave to convex above with two narrow lateral grooves decurrent from the base of the leaflets, subangular, convex beneath. Leaflets in 35–60 pairs, with stomata on both surfaces, tapered to a pungent apex, narrowed at the base to an anterior callus that is usually cream to yellow-orange in contrast to the dull green of the leaflet, angled forward acutely, spread wide, the uppermost crowded, the lower ones 2–4 cm (0.8–1.6 in) apart, rather stiff, lowest leaflets reduced and spinelike, median leaflets usually 15–20 cm (6–8 in) long, 5–10 mm (0.2–0.4 in) wide, margins flat and entire. Generally, most of the lower leaflets are dichotomously once divided at an acute angle, the division usually taking place near the base of the leaflets, but it may start at the midpoint in leaflets toward the apex of the leaf. In some plants more than one division takes place in a leaflet, producing three, four, or more segments. Some individuals may display no branching of the leaflets. **Female cones** solitary, rarely two, cylindrical ovoid, 15–20 cm (6–8 in) long, 8–12 cm (3.2–4.7 in) in diameter, glaucous. Peduncle erect, 5–15 cm (2–5.9 in) long, 2 cm (0.8 in) in diameter. Sporophyll face 12–18 mm (0.5–0.7 in) high, 40–45 mm (1.6–1.8 in) wide, apical spine flattened, erect or spreading, 2–25 mm (to 1 in) long, longest at the cone apex. Sarcotesta red or yellow when ripe. Sclerotesta subglobose to ovoid, 28–30 mm (1.1–1.2 in) long, 20–23 mm (0.8–0.9 in) in diameter, more or less smooth. **Male cones** one or two or more, erect, spindle shaped, 20–29 cm (8–11 in) long, 4–7 cm (1.6–2.8 in) in diameter, glaucous. Peduncle 8–12 cm (3.2–4.7 in) long, 2 cm (0.8 in) in diameter. Sporophylls 23–25 mm (0.9–1 in) long. Sporophyll face 12–18 mm (0.5–0.7 in) high, 20–30 mm (0.8–1.2 in) wide, bisected by a median ridge from the center of which arises the terminal spine, 2 mm long at the cone base, to 23 mm (0.9 in) long at the apex. **Habitat:** Flat to hilly, more or less open, dry *Eucalyptus* woodland, in sandy or stony siliceous soils, at elevations up to 500 m (1600 ft). Rainfall averages 735 mm (29 in) annually, falling mainly in summer. Annual temperatures range from highs of 35°C (95°F) and lows of −3.9°C (25°F), with frequent frosts in winter. **Distribution:** Australia, northwestern New South Wales, Coonabarabran district and the eastern foothills of the Warrumbungle Range, east to the Mooki River.

At one time the *Macrozamia heteromera* complex was thought to include all macrozamias with divided leaflets. In 1959 Lawrence A. S. Johnson separated two new species from the *M. heteromera* populations, *M. diplomera* and *M. stenomera. Macrozamia diplomera* was further separated into section *Macrozamia* whereas *M. heteromera* and *M. stenomera* were placed in section *Parazamia. Macrozamia diplomera* can be separated from the other two species by its larger size, larger number of leaves, which are flat, more angular rachis, markedly callous leaflet bases, and usually, reduced lower leaflets. In some areas, *M. diplomera* overlaps the range of *M. heteromera* and hybridization has been reported to have taken place. There does not appear to be a similar overlap with *M. stenomera,* or of *M. heteromera* with *M. stenomera.*

Macrozamia diplomera is most noteworthy for its divided leaflets, a feature it shares with *M. heteromera* and *M. stenomera.* I have studied some stands of this species where very few if any of the leaflets were divided, and other areas where its leaflets were divided more than once. *Macrozamia diplomera* must be considered extremely variable.

Macrozamia diplomera is not a particularly handsome cycad and thus has not been popular in gardening. It can be difficult in cultivation, with large, reestablished plants often dying for no apparent reason. This does not seem to be a problem with plants grown from seedlings. Such deaths may be the result of cultivating this cycad in soil that is too heavy, and in areas of winter rainfall.

In portions of its range, *Macrozamia diplomera* is quite common and exhibits good seedling regeneration. Coning appears to be somewhat cyclic with the production of female cones sparse in most years, common in others. *Macrozamia diplomera* has been involved in stock poisoning, which has no doubt reduced its numbers through eradication attempts in some areas. For these reasons, this species must be considered threatened.

Macrozamia douglasii W. Hill ex F. M. Bailey 1883

PLATES 369, 370

Macrozamia douglasii is named in honor of John Douglas (1828–1904), who was born in London, went to Victoria, Australia, during the gold rush in 1851, and moved to Queensland in 1863, where he was elected premier in 1877. **Stems** usually subterranean but sometimes emergent and arborescent, 0.6–1 m (2–3.3 ft) tall in hard or rocky soils, 40–70 cm (16–28 in) in diameter. **Leaves** as many as about 90 in mature plants, erect to spreading, somewhat arching, bright to dark green, 2–2.5 m (6.6–8.2 ft) long, 40–50 cm (16–20 in) wide, flat. Petiole 40–60 cm (16–24 in) long, swollen and densely tomentose at the base, flat above, convex and angular below. Rachis sometimes slightly twisted. Leaflets in 60–100 pairs, much lighter below than above, angled forward about 40°, moderately crowded, becoming more crowded toward the apex and less so toward the base, lowest leaflets reduced to one or two pairs of long yellowish spines, median leaflets 25–38 cm (10–15 in) long, 7–12 mm (0.3–0.5 in) wide, linear lanceolate, dark glossy green above, paler below, with a prominent white callous base, margins flat and entire. **Female cones** usually solitary, erect to leaning, cylindrical to narrowly ovoid, 35–50 cm (14–20 in) long, 15–18 cm (6–7.1 in) in diameter, green. Peduncle 3–4.5 cm (1.2–1.8 in) long, 2–3 cm (0.8–1.2 in) in diameter. Sporophyll face 3–4 cm (1.2–1.6 in) high, 4–6 cm (1.6–2.4 in) wide, apical spine erect, 5–28 mm (0.2–1.1 in) long, longest at the cone apex. Sarcotesta orange to red when ripe. Sclerotesta 3.5–4 cm (1.4–1.6 in) long, 2–3 cm (0.8–0.9) in diameter, dark brown, more or less smooth except for about 14 indistinct longitudinal grooves. Chalaza protruding, 5–9 mm (0.2–0.4 in) in diameter. **Male cones** usually one to three, straight or curved, cylindrical, 20–35 cm (8–14 in) long, 5–7 cm (2–2.8 in) in diameter, green. Peduncle 20–35 cm (8–14 in) long, 2–3 cm (0.8–1.2 in) in diameter. Sporophyll face 1.5–2.5 cm (0.6–1 in) high, 2–3.5 cm (0.8–1.4 in) wide, apical spine erect, 5–40 mm (0.2–1.6 in) long, longest at cone apex. **Habitat:** Open forest and along the edges of rain forest, with some individuals ranging into the rain forest, in deep gray to white sands with the water table close to the surface. Rainfall averages 2000 mm (79 in) annually, falling mostly in summer. The climate is subtropical with hot, humid summers, temperatures reaching 31°C (88°F) during the day, dropping to 20°C (68°F) at night, and mild to cool winters, temperatures reaching 23°C (73°F) during the day, dropping to 7°C (45°F) at night. **Distribution:** Australia, Queensland, Frasier Island and the mainland immediately adjacent to it.

Macrozamia douglasii was described in 1883 from plants collected on Frasier Island, Queensland. Frasier Island is said to be the largest sand island in the world, measuring roughly 125 km (78 miles) long and 25 km (16 miles) across at it widest point. The island is blessed with a multitude of freshwater springs and lakes, and because of this it is host to many plant species. *Macrozamia douglasii* somewhat resembles a large *M. miquelii,* and this is why Lawrence A. S. Johnson (1959) placed it in synonymy under *M. miquelii.* There are, however, a number of differences between the two species. In 1993 David L. Jones reinstated *M. douglasii* to the rank of species. During a brief visit to Frasier Island I had the chance to study *M. douglasii.* It is a very robust cycad that differs from *M. miquelii* in several respects. Most remarkable is its large seeds, which are two to three times the size of those of *M. miquelii. Macrozamia douglasii* also has larger cones, stems, and leaves with large and conspicuous white callous leaflet bases, and only the basal one or two pairs of leaflets are reduced to spines.

In cultivation, *Macrozamia douglasii* is apparently a relatively fast growing species. Its large seeds, not much smaller that those of *M. communis,* give the seedling a good start with an abundance of stored nutrients. Single leaves are produced at regular intervals, so by the end of the first year the seedling may have a complement of five or six leaves. The dark green leaves and its large size make *M. douglasii* a handsome landscape plant. There have been reports that the cycad is frost tender. I have not grown this species for any period of time so I cannot verify this. In my experience, I have not found any macrozamias to be frost tender so would not expect it of this species. Overhead cover will help maintain the dark green color of *M. douglasii* and assist it in producing longer, more fernlike leaves.

The conservation status of *Macrozamia douglasii* is secure, as several of its populations are located within national parks. Its habitat on Frasier Island is not threatened, and even the scattered coastal mainland populations do not seem to be under pressure. For these reasons, *M. douglasii* is not considered threatened.

Macrozamia dyeri (F. Mueller) C. A. Gardner 1930

PLATE 371

Encephalartos dyeri F. Mueller 1885b, *Macrozamia preissii* subsp. *dyeri* (F. Mueller) J. Schuster 1932

Macrozamia dyeri is named in honor of William Turner Thiselton-Dyer (1843–1928), English botanist who did considerable work on the world's cycads. **Stems** arborescent, usually unbranched, erect, usually blackened by fire, 0.4–3 m (1.3–10 ft) tall, 0.5–1.2 m (1.6–3.9 ft) in diameter. **Leaves** usually 70–150, erect, semiglossy gray-green, straight to slightly arching, 1–2.2 m (3.3–7.2 ft) long, 30–50 cm (12–20 in) wide, moderately keeled. Petiole 26–63 cm (10–25 in) long, rounded above and angular below, yellowish green, with a swollen and tomentose base. Leaflets in 35–50 pairs, dull green above, lighter below, angled forward about 25°, crowded and overlapping in an upward direction, lower leaflets reduced to spines, median leaflets 33–45.5 cm (13–18 in) long, 12.5–17 mm (0.5–0.7 in) wide, linear lanceolate, apex with a stiff yellow spine, base narrowed into a whitish callous attachment, margin flat and entire. **Female cones** usually one to three, somewhat cylindrical, 45–50 cm (18–20 in) long, 15–20 cm (6–8 in) in diameter, yellowish green. Peduncle 10–15 cm (4–6 in) long. Sporophyll face wedge shaped, 3–4 cm (1.2–1.6 in) high, 5–6 cm (2–2.4 in) wide, apical spine erect, flattened, 2–50 mm (to 2 in) long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta ovoid, three-angled, 43–55 mm (1.7–2.2 in) long, 28–36 mm (1.1–1.4 in) in diameter, the surface generally smooth but exhibiting a few shallow, indistinct, longitudinal grooves. **Male cones** usually one to five, erect, somewhat curved, cylindrical, 48–62 cm (19–24 in) long, 10–14 cm (4–5.5 in) in diameter. Peduncle 10–18 cm (4–7.1 in) long. Sporophyll face 20–25 mm (0.8–1 in) high, 20–29 mm (0.8–1.1 in) wide, apical spine erect, flattened, yellowish, 2–22 mm (to 0.9 in) long, longest at the cone apex. **Habitat:** Sparse woodland and low scrub on deep calcareous beach sand deposits. Rainfall averages 600–800 mm (24–32 in) annually, falling mainly in winter. Summers are hot and dry, with daytime highs to 25°C (77°F), nighttime lows to 18°C (64°F), and winters are cool to cold, with daytime highs to 17°C (63°F), nighttime lows to 2°C (36°F). **Distribution:** Australia, Western Australia, near Esperance to as far east as Cape Arid, and west to Stokes Inlet.

In 1885 Ferdinand von Mueller described *Encephalartos dyeri* from the state of Western Australia. In 1930 Charles A. Gardner transferred the species to its correct genus, *Macrozamia.* In 1956 Gardner placed all the Western Australian populations of *Macrozamia* in *M. riedlei.* Then in 1959, Lawrence A. S. Johnson, following Gardner's determination, maintained *M. dyeri* in synonymy under *M. riedlei.* Johnson did express doubts as to the validity of this thinking when he stated, "While lacking personal field experience and sufficient herbarium materials of the Western Australian populations, I must follow Gardner in recognizing only a single species, though with reservations." In 1993 David L. Jones treated *M. dyeri* as a species, a position with which I agree.

Macrozamia dyeri is a massive cycad with a large crown of distinctive strongly keeled, semiglossy gray-green leaves held in an upright and slightly spreading arrangement. The stem is thick and robust, and in the wild almost continually black as a result of the annual fires. This cycad is also provided with contractile roots that maintain the stems of seedlings and immature plants below the soil surface, protecting them from fire and predators. The leaflets of *M. dyeri* are relatively few and broad, and the slender male cones have short apical spines.

In cultivation, *Macrozamia dyeri* is a very satisfactory cycad. It is reasonably fast growing, very cold tolerant, and decorative enough to please most gardeners and landscapers. Keeping this cycad healthy and growing at a good rate requires well-drained soil, summer heat, and generous applications of fertilizer. More recent reports of attacks on this cycad in its habitat by root rotting fungus underline the need for good drainage. The light conditions best suited to *M. dyeri* are full to filtered sun. As with other species in section *Macrozamia, M. dyeri* will hold many leaves in good condition if kept free of harmful insects. Keeping this cycad insect-free requires only the application of a good insecticide two or three times during the summer. The central crown should be heavily sprayed or drenched with an insecticide recommended for mealybugs or scale insects. The leaflets are so thick and tough that damage from chewing insects is rare. Cold tolerance is good in *M. dyeri,* and I have not observed leaf damage at temperatures as low as –2°C (28°F).

The conservation status of *Macrozamia dyeri* is good. If conditions in its habitat do not change drastically, this species should continue to remain in its status as not threatened.

Macrozamia elegans K. D. Hill & D. L. Jones in Hill et al. 1998

PLATE 372

The epithet for *Macrozamia elegans* is Latin for elegant, referring to this cycad's appearance. **Stems** subterranean, 15–30 cm (6–12 in) in diameter. **Leaves** usually 3–10 in a crown, semiglossy gray-green, much lighter below than above, 1.1–1.5 m (3.6–4.9 ft) long, about 38 cm (15 in) wide, moderately keeled. Petiole terete, 20–35 cm (8–14 in) long, and about 1.3 cm (0.5 in) in diameter. Rachis not twisted spirally or moderately so. Leaflets in 45–70 pairs, basal leaflets not reduced to spines, median leaflets 21–32 cm (8.3–13 in) long, 9–14 mm (0.4–0.6 in) wide, at the attachment with orange to red callous bases, apex tipped with a spine, margin flat to curved slightly backward and downward, entire. **Female cones** solitary, ovoid, 24–26 cm (9.4–10 in) long, 11.5–12 cm (4.5–4.7 in) in diameter. Peduncle about 24 cm (9.5 in) long, 27 mm (1.1 in) in diameter. Sporophyll face flattened, 2.5–4 cm (1–1.6 in) high, 4.5–7.5 cm (1.8–3 in) wide, apical spine 2–5.5 cm (0.8–2.2 in) long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta ovoid, 30–32 mm (1.2–1.3 in) long, 24–26 mm (0.9–1 in) in diameter, tan, the surface with a network of indistinct fissures. **Male cones** solitary, erect, narrowly ovoid, 16–32 cm (6.3–13 in) long, 6–6.5 cm (2.4–2.6 in) in diameter. Sporophylls about 25 mm (1 in) long and 23 mm (0.9 in) wide, apical spine 1–10 mm (to 0.4 in) long, longest at the cone apex. **Habitat:** Dry sclerophyll woodland in undulating country dominated by sandstone boulders and outcrops, most commonly on flats or on east- or west-facing slopes, in soils of decomposed sandstone mixed with humus, at elevations of roughly 120–150 m (390–490 ft). **Distribution:** Australia, New South Wales, a limited area around Mountain Lagoon north and west of Richmond in the lower Blue Mountains.

In February 1995 I was fortunate to be shown what would become *Macrozamia elegans* in its habitat by Kenneth D. Hill. Then, it was referred to as the giant *spiralis.* We were searching for both female and male cones so that its description could be completed. Luckily, we were successful in finding a single female cone that was almost ripe, and two dry male cones on another plant nearby. It is truly a beautiful *Macrozamia,* and I was impressed by both its size and form. The gray-green leaves, with orange to red callous bases, make it striking. It was first collected in 1954 but was not then recognized as undescribed.

I am not aware of any plants in cultivation, but I am sure that some must have been removed to gardens in the past. Judging by its habitat, it should do well in cultivation and be very frost hardy. Cultivation, with the availability of water and fertilizer, should enhance both the growth rate and number of leaves produced. Even if there were no improvement it would still be a very beautiful and desirable cycad.

The conservation status of *Macrozamia elegans* is not very secure. Its habitat is relatively limited in size and not difficult of access. It is, however, conserved in the Blue Mountains National Park. The beauty of this cycad, coupled with its naming as a species, will no doubt bring pressure to bear on the wild populations. Although *M. elegans* is locally common, populations are scattered. The cycad is vulnerable to poaching and habitat destruction. A classification of vulnerable would seem prudent.

Macrozamia fawcettii C. Moore 1884

PLATE 373, 374

Macrozamia spiralis var. *fawcettii* (C. Moore) Maiden & Betche 1916

Macrozamia fawcettii was named in honor of C. Fawcett, a police magistrate who discovered this cycad. **Stems** mostly subterranean, rarely branched, 10–20 cm (4–8 in) in diameter, covered with a persistent tomentum. **Leaves** 2–12, at first erect, later spreading, 0.6–1.2 m (2–3.9 ft) long, 30–50 cm (12–20 in) wide. Petiole 15–30 cm (6–12 in) long, 6–11 mm (0.2–0.4 in) in diameter. Rachis strongly spirally twisted through two to eight revolutions, flat to strongly keeled and two-furrowed above. Leaflets in 25–60 pairs, angled forward about 60°, more or less spreading, twisted at the base so as to face toward the leaf apex, crowded in the upper part of the leaf but the lower leaflets 2–3 cm (0.8–1.2 in) apart, lowest leaflets may be reduced but not spinelike, median leaflets curved backward and downward, falcate, drooping, broad linear, broadest above the midpoint, 18–30 cm (7.1–12 in) long, 9–17 mm (0.4–0.7 in) wide, rounded toward the toothed apex, gradually tapered toward the usually reddish or pinkish callous attachment, dull dark green above, lighter below, with stomata only on the lower surface, margin entire except for two to seven teeth at or near the apex. **Female cones** solitary, erect, cylindrical to ovoid, 12–23 cm (4.7–9.1 in) long, 7–11 cm (2.8–4.3 in) in diameter, inner parts of the cone salmon pink when ripe. Peduncle 12–15 cm (4.7–6 in) long, 13–20 mm (0.5–0.8 in) in diameter. Sporophyll face 15–23 mm (0.6–0.9 in) high, 40–55 mm (1.6–2.2 in) wide, apical spine flattened, erect to spreading, 3–10 mm (to 0.4 in) long at the cone base, 15–25 mm (0.6–1 in) long at the apex, 4–9 mm (to 0.4 in) wide at its base. Sarcotesta scarlet when ripe. Sclerotesta 24–30 mm (0.9–1.2 in) long, 20–23 mm (0.8–0.9 in) in diameter, more or less smooth or with numerous irregular and somewhat indistinct shallow longitudinal grooves. Chalaza distinct and extended. **Male cones** usually one to four, cylindrical, 10–25 cm (4–10 in) long, 4–6 cm (1.6–2.4 in) in diameter. Peduncle 8–12 cm (3.2–4.7 in) long, 2 cm (0.8 in) in diameter. Sporophylls 1.5–2.5 cm (0.6–1 in) long. Sporophyll face 1–2 cm (0.4–0.8 in) wide, apical spine flattened, erect to spreading, 1–18 mm (to 0.7 in) long, longest near the cone apex. **Habitat:** Understory of dry or semiwet sclerophyll forest on poor siliceous soils, generally at elevations of 5–100 m (15–330 ft) but to 550 m (1800 ft) in the Richmond Range. Rainfall is 1375–1708 mm (54–67 in) annually, falling throughout the year. The average daily maximum temperature in the warmest month is 26°C (79°F) and the average nightly minimum in the coldest month is 4°C (39°F), with the lowest recorded 2°C (36°F). Frosts are uncommon and occur only 6–10 nights per season. **Distribution:** Australia, New South Wales, northern coast along the Richmond River, and Grafton and Casino districts.

In 1883, material was collected along the upper reaches of the Richmond River in northeastern New South Wales, which Charles Moore used for his description in 1884. *Macrozamia fawcettii* is a remarkable small cycad with broad, linear leaflets and spiral, upright to spreading leaves. When first seen in the wild, the leaves of this cycad remind one of a small *Podocarpus*. With a ripe female cone, it is a beautiful sight as a result of the contrast of the green cone and leaves and the vivid red seeds that are visible in the cone.

Macrozamia fawcettii is not often seen in cultivation outside Australia. Because of its unique growth habit, it is a worthwhile addition to any cycad collection. It is a reasonably easy plant to cultivate and will withstand several degrees of frost without damage. It does best in a somewhat shaded location, which preserves the dark green color of its leaves. Grown from seed, it is considerably more rapid in growth than most other species of section *Parazamia* and should produce a reasonably sized specimen in a few years. The number of leaves per crown is small, usually 2–10, but *M. fawcettii* is so distinctive it is well worth the time and effort to grow.

Macrozamia fawcettii is not very common over its range and numerous plants have been removed for cultivation in more recent years. Seed production is sporadic with female cones produced every 3–5 years, and seedling regeneration does not seem to be prolific. For these reasons, it must be considered threatened and measures should be taken to conserve this cycad in some of its remaining habitat.

Macrozamia fearnsidei D. L. Jones 1991

PLATES 375, 376

Macrozamia fearnsidei is named in honor of Geoff Fearnside, owner of Wallaroo station, Queensland, Australia, for his conservation of this species and other cycads growing there. **Stems** subterranean, densely tomentose, somewhat ovoid, 15–35 cm (6–14 in) in diameter, some old individuals with numerous crowns and measuring as much as 1 m (3.3 ft) across. **Leaves** 5–20 in an erect bushy crown, 0.7–1.4 m (2.3–4.6 ft) long, 30–75 cm (12–30 in) wide. Petiole dark dull green, semiterete, 15–40 cm (6–16 in) long, 8–10 mm (0.3–0.4 in) in diameter at the lowest leaflets. Rachis twisted spirally one to five times, giving each leaf a plumelike appearance. Leaflets in 55–120 pairs, linear, angled forward acutely, crowded, glossy dark green above, paler below, with stomata only on the lower surface, upper surface concave in cross section, 20–60 cm (8–24 in) long, the longest at the midsection, 6–11 mm (0.2–0.4 in) wide, with 9–12 prominently raised veins, basal leaflets only slightly reduced in length, leaflet base with a cream to pale yellow callus, margin flat, curved inward. **Female cones** solitary, erect, slightly ovoid, 12–18 cm (4.7–7.1 in) long, 8–10 cm (3.2–4 in) in diameter, cones ripening February–April. Peduncle furrowed, 18–27 cm (7.1–11 in) long, 15–22 mm (0.6–0.9 in) in diameter, somewhat elliptical in cross section. Sporophylls 1–1.5 cm (0.4–0.6 in) long. Sporophyll face ovate to kidney shaped, 10–15 mm (0.4–0.6 in) high, 17–28 mm (0.7–1.1 in) wide, with a prominent depression just below the apical spine, apical spine almost nonexistent at the cone base to about 2 cm (0.8 in) long at the apex. Sarcotesta yellow through orange to scarlet when ripe. Sclerotesta 23–27 mm (0.9–1.1 in) long, 19–23 mm (0.8–0.9 in) in diameter, tan, with 9–11 straight, shallow, longitudinal grooves, the area between the major grooves often webbed by random irregular grooves. **Male cones** solitary, at first erect, bending during and after pollen shedding, cylindrical, 15–27 cm (6–11 in) long, 4.5–6.5 cm (1.8–2.6 in) in diameter. Peduncle 18–30 cm (7.1–12 in) long, 12–18 mm (0.5–0.7 in) in diameter, terete to elliptical in cross section. Sporophylls 16–22 mm (0.6–0.9 in) long. Sporophyll face somewhat triangular, 1.5–2 cm (0.6–0.8 in) wide, in the basal section of the cone without spines, in upper parts the spines longer, longest at the apex, to 13 mm (0.5 in). Sporangia in a single somewhat heart-shaped patch. **Habitat:** Dry open *Eucalyptus* woodland in rocky, sandy soil, frequenting gullies and the banks of dry streams, occasionally in association with *Macrozamia moorei* and another cycad somewhat similar to *M. communis.* Rainfall averages 500–750 mm (20–30 in) annually, falling mainly in summer. Summers are hot with daytime highs of about 35°C (95°F), and winters cold with daytime highs of 21°C (70°F) and nighttime lows of about 6°C (43°F). Heavy frosts are common. **Distribution:** Australia, Queensland, Expedition Range to the north of Injune, and possibly adjacent ranges.

Macrozamia fearnsidei was first noticed botanically in the early 1980s during a field trip of the Brisbane chapter of the Australian Palm and Cycad Society. This field trip was made to study *M. moorei* in its habitat at Wallaroo station near Injune, Queensland. The owner of the station mentioned that there were one or two smaller forms growing a short distance away. These were investigated and two types of smaller cycads were found. One was obviously in section *Parazamia* and related to the *M. pauli-guilielmi* complex. This plant became known as *M.* "Injune" and was subsequently described as *M. fearnsidei.* The other plant somewhat resembles *M. communis* and was considered to be a hybrid between *M. moorei* and *M. fearnsidei.* I have not seen this plant in habitat but have observed a specimen in the collection of Stan Walkley of Burpengary, Queensland. It did not display features of either of the supposed parents and may be an additional, undescribed species. More fieldwork will be needed to assess its status properly.

Macrozamia fearnsidei is one of the most beautiful species of section *Parazamia.* Its numerous leaves, as many as 20 per crown, are distinctive because of the flattened, spirally twisted rachis and the long, broad leaflets. This species is one of the most robust of the section, producing leaves to 1.4 m (4.6 ft) long. In spite of its beauty and robust growth, *M. fearnsidei* is not often encountered in cultivation. There are two reasons for this, the first that its habitat is on private property, the second that the owner, Geoff Fearnside, is trying to conserve these plants in their natural habitat. This is a very commendable attitude since most cattlemen try to eradicate cycads on their property because of the danger of stock poisoning. Fearnside's interest in conserving these cycad populations resulted in the cycad's being named in his honor.

Seed of *Macrozamia fearnsidei* has been collected in considerable amounts and the species is available for cultivation as seedlings. The seedlings appear robust and relatively fast growing. Seed propagation of this fine cycad will in time make it available in large numbers and should aid in the conservation of the species.

The conservation status of *Macrozamia fearnsidei* is good with a fairly large population of plants over a wide range, producing large quantities of seed. Regeneration is good, and it does not appear that this cycad is threatened.

Macrozamia flexuosa C. Moore 1884

PLATES 377, 378

Macrozamia spiralis var. *flexuosa* (C. Moore) Maiden & Betche 1916, *M. pauli-guilielmi* subsp. *flexuosa* (C. Moore) L. A. S. Johnson 1959

Macrozamia flexuosa, the epithet Latin and meaning bent in several directions, referring to the twisted rachis, is called kangaroo nut. **Stems** subterranean, ovoid, 10–25 cm (4–10 in) in diameter, often with more than one crown, and covered by an armor of densely woolly leaf bases. **Leaves** usually 2–10, erect, then spreading, twisted through at least two complete revolutions, 0.6–1 m (2–3.3 ft) long, 30–50 cm (12–20 in) wide. Petiole almost round or only slightly flattened above, 20–35 cm (8–14 in) long, 4–8 mm (to 0.3 in) in diameter. Leaflets in 40–75 pairs, crowded, concave above, 17–30 cm (6.7–12 in) long, 3–6 mm (to 0.2 in) wide, medium green with a yellow to reddish callous base at the attachment, margin inrolled and entire. **Female cones** solitary, ovoid to short cylindrical, 10–25 cm (4–10 in) long, 7–11 cm (2.8–4.3 in) in diameter, glaucous. Peduncle 8–12 cm (3.2–4.7 in) long, 1.5–2 cm (0.6–0.8 in) in diameter. Sporophyll face 15–30 mm (0.6–1.2 in) high, 36–60 mm (1.4–2.4 in) wide, apical spine spreading, erect, vestigial at the cone base, longest at the apex. Sarcotesta orange to red when ripe. Sclerotesta 21–27 mm (0.8–1.1 in) long, 17–22 mm (0.7–0.9 in) in diameter, light tan, with a network of about 17 faint, irregular, longitudinal grooves. Male cones solitary, erect, spindle shaped, 8–25 cm (3.2–10 in) long, 4–6 cm (1.6–2.4 in) in diameter, glaucous. Peduncle 8–12 cm (3.2–4.7 in) long, 1.5–2 cm (0.6–0.8 in) in diameter. Sporophylls about 1.5 cm (0.6 in) long. Sporophyll face 13–20 mm (0.5–0.8 in) high, 15–23 mm (0.6–0.9 in) wide, apical spine upright, 5–35 mm (0.2–1.4 in) long, longest at the cone apex. Sporangia in a single heart-shaped patch. Habitat: Sclerophyll woodland in siliceous soils and shallow clay loams. Rainfall averages 875 mm (34 in) annually, falling mainly in summer and fall. Summers are hot and winters cold, with frequent frosts in inland areas. Distribution: Australia, New South Wales, northern and central coast from Bulahdelah through the Newcastle district to Morisset.

Charles Moore described *Macrozamia flexuosa* in 1884 from a specimen collected by Ernst Betche in 1883 on Limeburner's Creek, New South Wales. In 1959 Lawrence A. S. Johnson reduced it to a subspecies of *M. pauli-guilielmi,* believing it one of three intergrading geographic races, the third being subspecies *plurinervia.* When the range limits of the three subspecies became better known, it was found that in fact they did not overlap nor the taxa intergrade. In 1991 David L. Jones reestablished *flexuosa* as a distinct species and elevated *plurinervia* to the same rank, a move with which I heartily agree.

Macrozamia flexuosa is fairly common both in the wild and in cultivation, the latter no doubt because of easy access to its habitat and reasonably large colonies from which to collect. It is similar to the other members of section *Parazamia* in its relatively slow growth. *Macrozamia flexuosa* is worth the investment of time it takes to grow the plant because of its interesting plumelike leaves combined with its small stature. This cycad is easily grown from seed and develops quite rapidly into a multiple-leaved plant. There are no data of which I am aware that give us the amount of time needed to progress from seedling to coning specimens. I have no doubt that this process in nature is painfully slow and must take many years.

The conservation status of *Macrozamia flexuosa* is better than that of the majority of species of section *Parazamia.* Even though it is definitely threatened, it occurs in greater numbers and over a larger range than most of its close relatives. Overcollecting and land clearance could change its status from threatened to endangered in a short time.

Macrozamia fraseri Miquel 1842

PLATES 379, 380

Encephalartos fraseri (Miquel) Miquel 1863

Macrozamia preissii Lehmann 1844, *Encephalartos preissii* (Lehmann) F. Mueller 1859

Encephalartos oldfieldii Miquel 1863, *Macrozamia oldfieldii* (Miquel) A. de Candolle 1868

Macrozamia fraseri is named in honor of Charles Fraser (1788?–1831), a government botanist and "colonial collector" who traveled widely in Australia from 1816 until his death. Stems subterranean to arborescent, to 3 m (10 ft) long, 40–70 cm (16–28 in) in diameter, crown densely woolly. Leaves usually 30–100, dull to semi-glossy gray-green, 1.4–2.7 m (4.6–8.9 ft) long, 20–30 cm (8–12 in) wide, moderately keeled. Petiole terete, 18–55 cm (7.1–22 in) long. Rachis not twisted. Leaflets in 56–87 pairs, basal leaflets reduced to spines, median leaflets 18.5–34 cm (7.3–13 in) long, 7.5–14 mm (0.3–0.6 in) wide, lanceolate with an apical spine, the lower surface the same color as the upper or slightly lighter, margin flat and entire. Female cones solitary, ovoid, 35–45 cm (14–18 in) long, 15–17 cm (6–6.7 in) in diameter. Peduncle 15–20 cm (6–8 in) long. Sporophylls 8–10 cm (3.2–4 in) long. Sporophyll face 2.5–3.5 cm (1–1.4 in) high, 4.5–6 cm (1.8–2.4 in) wide, apical spine upright, 5–60 mm (0.2–2.4 in long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta irregularly ovoid, 37–50 mm (1.5–2 in) long, 25–30 mm (1–1.2 in) in diameter, flattened, smooth except for some indistinct longitudinal grooves. Male cones solitary to several, spindle shaped, 40–80 cm (16–32 in) long, 10–14 cm (4–5.5 in) in diameter. Peduncle short, glabrous. Sporophylls 2.5–5 cm (1–2 in) long. Sporophyll face 17–26 mm (0.7–1 in) wide, apical spine upright, 1.5–9 cm (0.6–3.5 in) long, longest at the cone apex. Habitat: Shrublands and heathlands, usually on deep sand. Distribution: Australia, Western Australia, from Enneabba south to Perth.

Macrozamia fraseri was described by Friedrich Anton Wilhelm Miquel in 1842 and was considered a distinct species until 1956 when Charles A. Gardner put it into synonymy under *M. riedlei.* In 1959 Lawrence A. S. Johnson followed Gardner's lead in recognizing only a single species in Western Australia "though with reservations." David L. Jones recognized *M. fraseri* as a distinct species again in 1998 (Hill et al. 1998).

Macrozamia fraseri is closely related to *M. riedlei* and the ranges of the two may in fact overlap in some areas. Immature plants might be difficult to separate in the absence of cones, but the adults leave no doubt. The stems of *M. fraseri* are well developed aboveground whereas those of *M. riedlei* are basically subterranean. In general, *M. fraseri,* with its robust and often arborescent habit, keeled leaves, large cones, and densely woolly crown, is distinguished from *M. riedlei,* which has a subterranean stem, flat glossy leaves, and small cones.

In cultivation, *Macrozamia fraseri* grows well and displays a good tolerance of cold. Its sandy habitat would suggest a need for good drainage. Growing it in full sun does not result in any adverse effects and in most cases produces a healthier plant.

The conservation status of *Macrozamia fraseri* is very good with large populations of plants the norm rather than the exception. The species may be considered as not threatened.

Macrozamia glaucophylla D. L. Jones in Hill et al. 1998

PLATES 381, 382

Macrozamia heteromera var. *glauca* C. Moore 1884

The epithet for *Macrozamia glaucophylla* is derived from *glauco-,* Greek for glaucous or gray, and *phyllon,* leaf, referring to the gray leaves. **Stems** subterranean, 20–40 cm (8–16 in) in diameter. **Leaves** usually two to eight in a crown, dull gray-green to blue, 0.6–1.2 m (2–3.9 ft) long, strongly to moderately keeled. Petiole 12–25 cm (4.7–10 in) long, 9–12 mm (0.4–0.5 in) in diameter at the lowest leaflets. Rachis moderately twisted. Leaflets in 45–60 pairs, basal leaflets not reduced to spines, median leaflets usually dichotomously divided but sometimes not, 16–24 cm (6.3–10 in) long, 4–7 mm (to 0.3 in) wide, apical segments 3–5 mm (to 0.2 in) wide, apex without a spine, margin flat and entire. **Female cones** generally solitary, ovoid, 18–23 cm (7.1–9.1 in) long, 9–11 cm (3.5–4.3 in) in diameter. Peduncle 15–20 cm (6–8 in) long, 2.5–3.5 cm (1–1.4 in) in diameter. Sporophyll face 2–3 cm (0.8–1.2 in) high, 5–6 cm (2–2.4 in) wide, apical spine 2–10 mm (to 0.4 in) long, longest at the cone apex. Sarcotesta orange-red when ripe. Sclerotesta ovoid, 30–34 mm (1.2–1.3 in) long, 24–26 mm (0.9–1 in) in diameter. **Male cones** usually one to three, cylindrical, 20–30 cm (8–12 in) long, 5–6.5 cm (2–2.6 in) in diameter. Peduncle 15–20 cm (6–8 in) long, 1.5–2.5 cm (0.6–1 in) in diameter. Sporophylls 20–24 mm (0.8–0.9 in) long, 19–22 mm (0.8–0.9 in) wide, apical spine 2–15 mm (to 0.6 in) long, longest at the cone apex. **Habitat:** Flat, dry sclerophyll woodlands on deep red sands. Rainfall averages 550–650 mm (22–26 in) annually, falling mainly in spring and summer. The climate is temperate, with summer highs of 34°C (93°F), lows of 19°C (66°F), and winter highs of 18°C (64°F), lows of 0°C (32°F). Heavy frosts are common during winter. **Distribution:** Australia, northern New South Wales, in the vicinity of Narrabri and Gunnedah in the area of the northern Pilliga scrub.

Macrozamia glaucophylla has been known since the nineteenth century. Charles Moore first described it in 1884 as *M. heteromera* var. *glauca.* This cycad is definitely part of the *M. heteromera* complex because of its growth habit and sometimes dichotomously divided leaflets. It is easily separated from *M. heteromera* by its larger crown of consistently longer, blue or blue-green leaves with less-divided leaflets and larger cones.

Macrozamia glaucophylla grows well in cultivation though somewhat slowly. The beauty of this species makes it well worth the effort. Seed is not always available as the coning of *M. glaucophylla* is cyclical and 3–5 years generally pass between periods of heavy coning. This cycad has very good frost tolerance and will grow quite well in full sun. The very blue-gray leaves make *M. glaucophylla* a fine accent plant for use in garden plantings.

The conservation status of *Macrozamia glaucophylla* is good with sporadic but locally abundant populations over a fairly large distributional area. Many of the habitats are remote and relatively secure from poaching. The beauty of this cycad and its elevation to the rank of species in 1998 will no doubt bring more pressure on the known populations, but at present *M. glaucophylla* can be classified as not threatened.

Macrozamia heteromera C. Moore 1884

PLATES 383, 384

Macrozamia spiralis var. *heteromera* (C. Moore) Maiden & Betche 1916

Macrozamia heteromera f. *harmsii* J. Schuster 1932

The epithet for *Macrozamia heteromera* is derived from *heteros,* Greek for different, and *meris,* part, and meaning not corresponding in number, referring to the often forked leaflets. **Stems** subterranean, 8–15 cm (3.2–6 in) in diameter, the persistent leaf bases and cataphylls densely covered with a light brown tomentum. **Leaves** usually 2–10 in a crown, rarely as many as 20, at first erect but later spreading, 45–80 cm (18–32 in) long, 15–20 cm (6–8 in) wide, usually keeled. Petiole 5–12 cm (2–4.7 in) long, 6–10 mm (0.2–0.4 in) in diameter. Rachis not twisted or twisted through one-quarter to one-half revolution, usually toward the apex, curved backward and downward throughout its length but usually curved slightly inward at the apex, flat or concave and sometimes slightly keeled above in the basal portion, more or less rounded in the apical portion, round convex below. Leaflets in 40–65 pairs, dull green or quite glaucous, with stomata on both surfaces, more or less spreading or more often suberect, forwardly directed, twisted at the base so as to face toward the apex of the leaf, rather crowded but the basal leaflets 1.5–4.5 cm (0.6–1.8 in) apart, rigid, most once or twice dichotomously divided near the base, rarely thrice, but sometimes divided in the upper half, infrequently with entire leaflets, lowest leaflets not greatly reduced in length and never spinelike, median leaflets 10–20 cm (4–8 in) long, entire leaflets 3–7 mm (to 0.3 in) wide, segments 2–5 mm (to 0.2 in) wide, abruptly rounded or sometimes two-toothed at the apex, narrowed toward a yellowish, slightly callous base, margin flat, entire. **Female cones** usually solitary, ovoid cylindrical, 12–27 cm (4.7–11 in) long, 8–13 cm (3.2–5.1 in) in diameter, glaucous, inner parts of the cone salmon pink when ripe. Peduncle 15–20 cm (6–8 in) long, 2–3 cm (0.8–1.2 in) in diameter. Sporophylls 3–4 cm (1.2–1.6 in) long. Sporophyll face 1.5–4 cm (0.6–1.6 in) high, 3.5–8.5 cm (1.4–3.3 in) wide, apical spine flattened, more or less erect, shortest 2–5 mm (to 0.2 in) at the cone base, longest 10–20 mm (0.4–0.8 in) long at the apex, 3–10 mm (to 0.4 in) wide at its base. Sarcotesta scarlet when ripe. Sclerotesta irregularly ovoid, 27–35 mm (1.1–1.4 in) long, 20–25 mm (0.8–1 in) in diameter, tan, the surface smooth. Chalaza often with irregular pits. **Male cones** one to four, cylindrical, 12–20 cm (4.7–8 in) long, 4–5 cm (1.6–2 in) in diameter. Peduncle 15–20 cm (6–8 in) long, 2 cm (0.8 in) in diameter. Sporophylls cuneate to obovate cuneate, 1.5–2 cm (0.6–0.8 in) long. Sporophyll face 1.5–2 cm (0.6–0.8 in) wide, apical spine flattened, erect, 0–14 mm (0.6 in) long, longest at the cone apex, 1–5 mm (to 0.2 in) wide at its base. **Habitat:** Dry sclerophyll forest in siliceous soils, often in open grassy areas at an elevation of about 200 m (650 ft). Rainfall averages 600 mm (24 in) annually, falling mainly in summer, November–March. The average daily maximum temperature during the warmest month is 32°C (90°F), and the average daily minimum during the coldest month is 4°C (39°F) with the lowest recorded −7°C (19°F). **Distribution:** Australia, drier areas of northern and northwestern New South Wales, mainly in the Warrumbungle Range.

Macrozamia heteromera, with its somewhat boat-shaped leaves and divided leaflets, is not only interesting but decorative. In its habitat the cycad grows on almost pure sand, in light shade to full sun. In cultivation it needs good drainage to promote healthy root growth, and bright light to keep the leaves compact and healthy. Seedlings usually display divided leaflets even with the first leaf. It is cold hardy to several degrees of frost and can also withstand hot, dry growing conditions. *Macrozamia heteromera* is not particularly fast growing, but with proper fertilization and sufficient water it will develop into a strong plant in a few years. Because of its small size, few leaves, and slow growth, *M. heteromera* will probably appeal only to collectors.

The conservation status of *Macrozamia heteromera* is not secure. Cone production in habitat is very sporadic, making seed collection difficult in most years. In years with abundant cone production, it seems that almost every female plant produces one or more cones. Seedling regeneration in habitat is quite sparse, so most colonies do not appear to be enlarging. The more recent collection of plants from the wild to supply ever increasing demand from collectors and nurseries must pose a threat to the survival of this species. Protection should be provided to this cycad before its conservation condition becomes critical. For these reasons, *M. heteromera* must be considered threatened.

Macrozamia humilis D. L. Jones in Hill et al. 1998

PLATES 385, 386

The epithet for *Macrozamia humilis* is Latin for low or low growing, referring to the small size of this cycad. **Stems** subterranean, 18–28 cm (7.1–11 in) in diameter. **Leaves** usually two to seven in a crown, dull to semiglossy, bright green to deep green or gray-green, 35–65 cm (14–26 in) long, moderately keeled. Petiole 9–16 cm (3.5–6.3 in) long, 6–8 mm (0.2–0.3 in) in diameter at the lowest leaflets. Rachis not twisted or moderately so. Leaflets in 30–45 pairs, basal leaflets not reduced to spines, median leaflets simple or dichotomously branched, slightly lighter in color below, 10–18 cm (4–7.1 in) long, 4–7 mm (to 0.3 in) wide, apex without a spine, margin flat and entire. **Female cones** solitary, erect, ovoid, 10–15 cm (4–6 in) long, 6–8 cm (2.4–3.2 in) in diameter. Sporophyll face 1.5–2 cm (0.6–0.8 in) high, 4–5 cm (1.6–2 in) wide, apical spine 2–25 mm (to 1 in) long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta ovoid to globose, 25–31 mm (1–1.2 in) long, 22–26 mm (0.9–1 in) in diameter, light tan, the surface somewhat roughened by numerous irregular longitudinal grooves. Chalaza not prominent, 10–12 mm

(0.4–0.5 in) in diameter, with a few shallow pits. **Male cones** solitary, erect, spindle shaped, 14–19 cm (5.5–7.5 in) long, 4.5–5.5 cm (1.8–2.2 in) in diameter. Sporophylls 14–20 mm (0.6–0.8 in) long, 11–18 mm (0.4–0.7 in) wide, apical spine 1–10 mm (to 0.4 in) long, longest at the cone apex. **Habitat:** Low dry sclerophyll woodland in sandy soils over granite. **Distribution:** Australia, northeastern New South Wales, known only from near Inverell in the Goonoowigal Nature Preserve.

Macrozamia humilis is part of the *M. heteromera* complex and was discovered in 1992 by David L. Jones. It can be separated from *M. heteromera* by its shorter, dull green to gray leaves with fewer leaflets. It is a small plant that is difficult to see in its habitat when mixed with grass and low brush. The plants occur in scattered small groups and do not seem to be common. When I visited its habitat in 1995 with Kenneth D. Hill, we were only able to locate two female cones. Seedling regeneration was not common, but overall the colony seemed healthy.

I have no reports of this species in cultivation. Some seed has been collected and I am sure that *Macrozamia humilis* will become available. It is not particularly pretty in the wild, but that may change in cultivation. It appears to be slow growing, which would not make it popular as a garden plant. Frost hardiness should be very good.

The conservation status of *Macrozamia humilis* is not secure. The species is only known from a small area where the plants are not overly common. The only known population is located in the Goonoowigal Nature Preserve, and that is in its favor. If poaching can be controlled, this small population should be secure. Because of the small numbers of *M. humilis* in the wild and its restricted range, it must be considered threatened. It is hoped that more populations will be discovered and that the conservation status can be upgraded.

Macrozamia johnsonii D. L. Jones & K. D. Hill 1992

PLATES 387, 388

Macrozamia johnsonii is named in honor of Lawrence Alexander Sidney Johnson (1925–1997) of the National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, because of his pioneering research on Australian cycads. **Stems** arborescent, upright or decumbent with age and large size, 1–1.5 m (3.3–4.9 ft) tall, and to 60 cm (24 in) in diameter. Cataphylls stiff and spinelike, 23–26 cm (9–10 in) long, 5–10 mm (0.2–0.4 in) wide at the base. **Leaves** as many as 150 in a crown, light green, 2.5–3 m (8.2–10 ft) long, about 61 cm (24 in) wide, flat or with the leaflets drooping. Petiole 3–30 cm (1.2–12 in) long, 5 cm (2 in) wide at the base, rounded above and below. Leaflets angled forward about 45°, constricted at the base and ending in a cream-colored swollen callus at the attachment, gradually reduced to spines below, somewhat reduced in length toward the leaf apex, median leaflets 36–44 cm (14–17 in) long, about 1 cm (0.4 in) wide, very gradually acuminate from just above the attachment toward the pungent and flexible apex, margin flat and entire. **Female cones** one to eight, at first upright, leaning at maturity, cylindrical, 40–90 cm (16–36 in) long, 12–19 cm (4.7–7.5 in) in diameter, glaucous, at maturity the inner surfaces of the sporophylls turning pinkish red. Peduncle 7.5–10 cm (3–4 in) long, 3 cm (1.2 in) in diameter, but the cone appearing sessile with the peduncle hidden among the leaf bases, and spinelike cataphylls at the base to 27 cm (11 in) long and 2.5 cm (1 in) broad at their base. Sporophylls 5–7 cm (2–2.8 in) long. Sporophyll face 2–3 cm (0.8–1.2 in) high, 5–8 cm (2–3.2 in) wide, glaucous, apical spine flattened, erect, arising from the medial ridge and about 1 cm (0.4 in) wide, from 2 cm (0.8 in) long at the cone base to 6 cm (2.4 in) long at the apex. Sarcotesta red-orange when ripe. Sclerotesta long ovoid, 37–45 mm (1.5–1.8 in) long, 20–25 mm (0.8–1 in) in diameter, tan, smooth. **Male cones** 1–10, long cylindrical, 55–65 cm (22–26 in) long, 10–12.5 cm (4–5 in) in diameter, glaucous green, base surrounded by numerous stiff, spinelike cataphylls. Peduncle 10–12.5 cm (4–5 in) long, 5 cm (2 in) in diameter. Sporophyll wedge shaped, 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 5 mm (0.2 in) high, 15–20 mm (0.6–0.8 in) wide, apical spine triangular, upright, 2–20 mm (to 0.8 in) long, longest at the cone apex. Sporangia in two patches. **Habitat:** Steep hillsides in shallow, rocky soil, in wet sclerophyll forest to the margins of rain forest, at elevations averaging about 300 m (1000 ft). Rainfall averages 875 mm (34 in) annually, falling mainly in summer, November–April. Frosts occur in June and July. **Distribution:** Australia, New South Wales, far northern coast in the Dalmorton district, mainly in the catchment of the Clarence River.

When Lawrence A. S. Johnson (1959) revised *Macrozamia,* he felt that the populations of plants in the area of Dalmorton, New South Wales, were the same species as *M. moorei* of Queensland. For this reason they were for many years referred to as the New South Wales *moorei* or green *moorei.* Johnson's decision was based in large part on herbarium material though he did conduct field studies of the Dalmorton populations. The main problem was that the dried, pressed herbarium material did not disclose the inherent differences between the two taxa. Their habitats are also quite different. The New South Wales plants grow in coastal conditions in wet sclerophyll forest to the margins of rain forest. The Queensland plants inhabit inland mountains in dry sclerophyll forest. They are separated by a distance of 700 km (430 miles). When the two are seen growing side by side, their differences are quite apparent. The New South Wales plants were described as a separate species, *M. johnsonii,* by David L. Jones and Kenneth D. Hill in 1992.

In cultivation, *Macrozamia johnsonii* grows well and relatively fast for a cycad. Johnson mentioned that a specimen grown from seed in the Royal Botanic Gardens, Sydney, produced a stem 2 m (6.6 ft) tall and 70 cm (28 in) in diameter in a little less than 100 years. In my experience, the growth rate of this cycad is very rapid. Given good soil and an abundance of water and fertilizer, a sizable plant can be expected in about 10 years. *Macrozamia johnsonii* is very cold tolerant and I have not observed foliar damage in plants that were fully exposed to several degrees below freezing. Care must be exercised when adding this cycad to the garden as they will generally grow much faster than expected. This cycad should be kept back from walks or other areas of foot traffic because the leaflets, though flexible, have a sharp, fine point at the apex. This is a truly graceful cycad with its numerous leaves gently arching and swaying in the slightest breeze. Because *M. johnsonii* carries so many leaves that are held upright to flat on the ground, it should not be used in foreground plantings where it will obscure the plants behind it.

Johnson reported the occurrence of a natural hybrid between *Macrozamia johnsonii* and *M. lucida,* and also hybrids produced at the Royal Botanic Gardens, Sydney, between *M. johnsonii* and other species of section *Parazamia.* Since all macrozamias are believed to have the same chromosome number $2n = 18$, hybridization between any of its species might be possible.

The conservation status of *Macrozamia johnsonii* is very good. Within their range these cycads are quite common, and regeneration is prolific. Viable seed is the norm rather than the exception, and it is easily germinated and grown. This species is not considered threatened.

Macrozamia lomandroides D. L. Jones 1991

PLATE 389

The epithet for *Macrozamia lomandroides* refers to *Lomandra,* a grasslike plant that this cycad resembles. **Stems** subterranean, somewhat ovoid, 10–17 cm (4–6.7 in) in diameter, crown densely covered with a persistent tomentum. **Leaves** usually two to six, erect or spreading, dull green, 30–80 cm (12–32 in) long, 40–60 cm (16–24 in) wide. Petiole semiterete, dull pale green, 6–14 cm (2.4–5.5 in) long, 8–10 mm (0.3–0.4 in) wide at the base, with a yellowish green stripe on the underside of the petiole continuing into the rachis. Rachis spirally twisted one to eight times, 1–1.5 cm (0.4–0.6 in) in diameter at the lowest leaflets. Leaflets in 25–45 pairs, crowded, leathery, straight or falcate, angled forward acutely, stiffly erect below and arching toward the apex, the longest toward the base of the leaf, median leaflets linear, dull dark green above, lighter below, 20–30 cm (8–12 in) long, 9–14 mm (0.4–0.6 in) wide, tapered to a long, narrow base, the callous attachment pale green to cream, the upper surface slightly concave in cross section, the underside with 10–16 raised veins, margins entire and flat except near the blunt leaflet apex where there are one to six teeth on the upper margin, one or two on the lower. **Female cones** solitary, erect, ovoid, 12–18 cm (4.7–7.1 in) long, 7–9 cm (2.8–3.5 in) in diameter, cones reported to ripen March or April. Peduncle 10–15 cm (4–6 in) long, 10–12 mm (0.4–0.5 in) in diameter, densely tomentose at its base. Sporophylls 7–10 mm (0.3–0.4 in) long. Sporophyll face 14–18 mm (0.6–0.7 in) high, 25–35 mm (1–1.4 in) wide, central spine upright, to 3 cm (1.2 in) long, longest at the cone apex, each with a prominent depression just below its attachment to the sporophyll face. Sarcotesta orange to red when ripe. Sclerotesta irregularly shaped from more or less globose to somewhat three- or four-sided, 22–26 mm (0.9–1 in) long, 18–22 mm (0.7–0.9 in) in diameter, light tan, the surface varying from relatively smooth to having 16–22 shallow irregular grooves. **Male cones** solitary, erect, cylindrical, 12–15 cm (4.7–6 in) long, 4–5 cm (1.6–2 in) in diameter. Peduncle 8–15 cm (3.2–6 in) long, 10–12 mm (0.4–0.5 in) in diameter, somewhat elliptical in cross section. Sporophyll face ovate, 14–18 mm (0.6–0.7 in) high, 25–35 mm (1–1.4 in) wide, with a prominent depression just below the base of the apical spine, apical spine to 3 cm (1.2 in) long, longest at the cone apex. Sporangia in a single somewhat rounded patch. **Habitat:** Flat open *Eucalyptus* woodland in association with grasses, in soil that is generally a gray silty loam but also reported from rocky habitats. Rainfall averages 2200 mm (88 in) annually, falling mainly in summer. The climate is subtropical, summers with a day–night temperature range of 30–20°C (86–68°F), winters 21–9°C (70–48°F). **Distribution:** Australia, central eastern Queensland, south of Bundaberg in scattered populations between the Elliot and Isis Rivers, and possibly adjacent areas.

When first reported in the early 1980s, *Macrozamia lomandroides* was considered to be a form of *M. pauli-guilielmi,* whose habitat is a few kilometers distant. In spite of the fact that the two species occur in relatively close proximity and in similar habitats, their populations do not overlap and there have been no reports of intermediates. The basic morphological differences between the two are well defined, with *M. lomandroides* producing larger stems, and leaves with very broad leaflets, in contrast to the leaflets of *M. pauli-guilielmi,* which are very narrow and channeled.

There do not appear to be any problems associated with *Macrozamia lomandroides* in cultivation. It is best suited to subtropical and warm temperate climates where it will grow well in full to filtered sun. It has proved to be very adaptable to various soil types and displays good tolerance of cold weather and frost. Grown from seed, this cycad produces distinctive short, untwisted leaves with broad leaflets ending in a blunt, toothed apex.

The small size of the plant and its handsome leaves make *Macrozamia lomandroides* a fine cycad for pots or small garden areas. It grows best in bright shade or in a position where it receives full sun only in the morning. As with other cycads, *M. lomandroides* benefits from soil with good drainage and regular application of fertilizer. Once plants are well established in cultivation, production of cones is frequent. Seed is easily set if pollen is available to fertilize the cones. When seed is shed from the cone it should be stored 4–6 months before planting. The storage allows the embryo to develop and results in a much higher rate of germination. The growth rate of the seedling is good though somewhat slow the first year or two. Once a large tuberous root is formed, the yearly growth rate increases to an acceptable level.

The conservation status of *Macrozamia lomandroides* is not good. Its habitat has been drastically reduced through land clearance for agriculture, and the small populations that remain are in jeopardy of the same fate. Because *M. lomandroides* is a handsome cycad, a considerable number have been removed from habitat since its discovery. For these reasons, *M. lomandroides* must be considered extremely endangered.

Macrozamia longispina P. I. Forster & D. L. Jones in Hill et al. 1998

The epithet for *Macrozamia longispina* is derived from *longus,* Latin for long, and *spina,* spine, referring to the long spines on the uppermost megasporophylls. STEMS usually subterranean, rarely as tall as 29 cm (12 in), 20–30 cm (8–12 in) in diameter. LEAVES usually 15–20, erect and arching, semiglossy to very glossy bright green, 1–1.5 m (3.3–4.9 ft) long, flat. Petiole 40–50 cm (16–20 in) long, 4–5 mm (0.2 in) wide at the lowest leaflets. Leaflets in 24–33 pairs, basal leaflets not reduced to spines, median leaflets 28–32 cm (11–13 in) long, 4.5–6 mm (0.2 in) wide, the lower surface much lighter in color than the upper, the margin flat and entire, with an apical spine. FEMALE CONES narrowly ovoid, 13–14 cm (5.1–5.5 in) long, 6–8 cm (2.4–3.2 in) in diameter. Sporophyll face 15–20 mm (0.6–0.8 in) high, 28–35 mm (1.1–1.4 in) wide, apical spine 25–62 mm (1–2.4 in) long, longest at the cone apex. Sarcotesta orange or yellow when ripe. Sclerotesta ovoid, 20–23 mm (0.8–0.9 in) long, 15–16 mm (0.6 in) in diameter, light brown, the surface more or less smooth except for eight or nine short ridges around the micropyle that turn into grooves as they continue toward the chalaza. MALE CONES spindle shaped, 8–15 cm (3.2–6 in) long, 2.5–3.5 cm (1–1.4 in) in diameter. Sporophylls 14–16 mm (0.6 in) long, 10–13 mm (0.4–0.5 in) wide, apical spine 1–20 mm (to 0.8 in) long, longest at the cone apex. HABITAT: Wet sclerophyll forests dominated by *Eucalyptus* and *Corymbia,* on relatively steep slopes of serpentine soils. DISTRIBUTION: Australia, southeastern Queensland, Widgee area west of Gympie.

Until its description in 1998, *Macrozamia longispina* was considered a weakly or imperfectly developed form of *M. miquelii.* It differs from *M. miquelii* in its smaller size, its long, unarmed petiole, and its lower leaflets, which are not reduced to spines. Its closest relative is *M. mountperriensis,* from which it differs in its leaves, with fewer leaflets, narrower median leaflets, and longer spines on the cones of both female and male plants.

Macrozamia longispina is an easily grown cycad of small size and pleasing appearance. Its leaves appear more feathery than those of *M. miquelii* and *M. mountperriensis* because of its long, narrow leaflets. It is not fast growing, as expected of a dwarf cycad, but its cold tolerance and ease of cultivation make it a rewarding garden plant.

Macrozamia longispina is considered as not threatened because its colonies are extensive and regeneration is prolific. The areas where it occurs are generally not suited for agriculture, and this also helps in its conservation.

Macrozamia lucida L. A. S. Johnson 1959

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The epithet for *Macrozamia lucida* is derived from *lucidus,* Latin for shining, referring to the very glossy surface of the leaflets. STEMS subterranean, rarely branched, 10–20 cm (4–8 in) in diameter, and densely tomentose. **Leaves** 5–40, at first erect, later spreading, glossy bright green, 0.8–1.1 m (2.6–3.6 ft) long, 45–50 cm (18–20 in) wide. Petiole 25–50 cm (10–20 in) long, 3–7 mm (to 0.3 in) in diameter. Rachis concave above, convex below, not or slightly twisted toward the apex. Leaflets in 25–50 pairs, spreading but the two ranks not in the same plane, upper leaflets forwardly directed and crowded, lower leaflets inserted at right angles to the rachis, 1–3 cm (0.4–1.2 in) apart, lowest leaflets not reduced to spines, median leaflets curved backward and downward, falcate in overall outline, linear, 15–25 cm (6–10 in) long, 7–11 mm (0.3–0.4 in) wide, gradually tapered toward a pungent apex, slightly narrowed at the attachment to a conspicuous whitish callous base, the upper surface bright glossy green, stomata only on the undersurface, margin flat and entire. **Female cones** one or two, long ovoid or cylindrical, 13–20 cm (5.1–8 in) long, 7–10 cm (2.8–4 in) in diameter, glaucous green, turning yellow at the edges of the sporophylls. Peduncle erect, 10–30 cm (4–12 in) long, 2–3 cm (0.8–1.2 in) in diameter, with numerous irregular grooves running its entire length and with an occasional prominent cataphyll. Sporophyll face 25–30 mm (1–1.2 in) wide, 15–18 mm (0.6–0.7) high, with a horizontal ridge dividing its upper and lower halves, with an upright spine arising from its central area, the spine 3–16 mm (to 0.6 in) long, longest at the cone apex, 3–6 mm (to 0.2 in) wide at its base. Sarcotesta dark orange when ripe. Sclerotesta irregularly ovoid, 2–2.5 cm (0.8–1 in) long, 1.5 cm (0.6 in) in diameter, tan, the surface more or less smooth except for a network of shallow, irregular fissures. Chalaza prominently projecting. **Male cones** one to eight or more, erect, cylindrical, 20–25 cm (8–10 in) long, 5–6.5 cm (2–2.6 in) in diameter, light glaucous green until the pollen is shed when it turns light cream-yellow with only the center of each sporophyll remaining green. Peduncle erect, 9.5–30 cm (3.7–12 in) long, 2 cm (0.8 in) in diameter, glaucous green, no cataphylls present except at the base. Sporophyll face 7 mm (0.3 in) high, 12–20 mm (0.5–0.8 in) wide, no spines in lower fourth to third of the cone, spines gradually appearing above, apical spine to about 15 mm (0.6 in) long toward the apex of the cone. Sporangia in a single regularly shaped patch. **Habitat:** Wet sclerophyll forest and rain forest in coastal to near coastal mountainous areas, usually in shaded situations and often near streams, at elevations of 100–300 m (330–990 ft). Rainfall averages 1000 mm (40 in) annually. The climate is subtropical, with hot, wet, humid summers. **Distribution:** Australia, southeastern Queensland, from just south of Gympie to Brisbane, especially common in the Glasshouse Mountains near Brisbane.

Macrozamia lucida, though included in section *Parazamia* by Lawrence A. S. Johnson (1959), exhibits many of the attributes of section *Macrozamia.* The number of leaves and the distinctive shape of the seed sclerotesta place *M. lucida* as a very close relative of *M. douglasii, M. longispina, M. miquelii,* and *M. mountperriensis,* which are all placed in section *Macrozamia.* In truth, the only reason for placing *M. lucida* in section *Parazamia* is its small size. As the taxonomy of the genus *Macrozamia* becomes better understood, we may find that *M. lucida* fits better into section *Macrozamia.*

Macrozamia lucida is a delightful little cycad that is easy to grow, forming a small plant with numerous glossy green leaves, and with a characteristic and conspicuous white callus at the base of each leaflet. It seems strange that this *Macrozamia,* possessing so many desirable characteristics, is not more common in cultivation. Its size makes it a fine pot plant and it takes well to container culture, unlike some other species of the genus. Its shaded habitat has prepared it to be grown as a houseplant or in a dark area of the garden without ill effects. All things considered, this is one of the better cycad species for the home gardener.

Macrozamia lucida is easy to grow from seed, which germinates readily. If given ample fertilizer and water, and well-drained soil, it will grow quite rapidly. It is cold tolerant to several degrees of frost, and I have never seen foliar damage from frost in the area of Los Angeles, California. The only insect pests seem to be mealybugs and scale insects, which are easily controlled with a wide range of insecticides. Cones are produced at a relatively small plant size, and cultivated plants usually produce cones yearly. The cones are very decorative as both the female and male turn green and yellow when mature. The female cones are readily pollinated, and the resultant red seeds produce an even more striking color contrast with the green and yellow sporophylls.

Macrozamia lucida has a relatively wide range and is comparatively common over most of it. This cycad reproduces well in habitat, and seedling regeneration is common. It is not considered threatened.

Macrozamia macdonnellii (F. Mueller ex Miquel) A. de Candolle 1868

PLATES 392, 393

Encephalartos macdonnellii F. Mueller ex Miquel 1863

The epithet for *Macrozamia macdonnellii* refers to the Macdonnell Ranges, southern Northern Territory, Australia, which form a large part of this cycad's habitat. **Stems** erect or decumbent, often suckering from the base or sometimes along the trunk of decumbent plants, 1–3 m (3.3–10 ft) long, 60–80 cm (24–32 in) in diameter. **Leaves** 50–120 or more, erect at first, then spreading or drooping, 1.5–2.2 m (4.9–7.2 ft) long, 30 cm (12 in) wide in mature plants. Petiole unarmed, 12–25 cm (4.7–10 in) long. Rachis not twisted or very slightly so, more or less flattened above and keeled below, 1.5–2.5 cm (0.6–1 in) in diameter at the lowest leaflets, with two narrow lateral grooves decurrent from the base of the leaflets. Leaflets in 60–85 pairs, spreading but slightly keeled below, more strongly keeled toward the apex, angled forward acutely, crowded above but the lowest usually 4–5 cm (1.6–2 in) apart, rigid, straight, entire, linear, lowest 8–20 leaflets gradually reduced and spinelike, median leaflets 20–30 cm (8–12 in) long, 7–11 mm (0.3–0.4 in) wide, gradually tapered to a pungent apex and narrowed at the base to a pink anterior callus, both surfaces very glaucous. **Female cones** one to five, ovoid cylindrical, 40–50 cm (16–20 in) long, 20–27 cm (8–11 in) in diameter, glaucous green. Peduncle 12–20 cm (4.7–8 in) long, 4–5 cm (1.6–2 in) in diameter, base surrounded by several spinelike cataphylls. Sporophylls 7–9 cm (2.8–3.5 in) long. Sporophyll face 4–6 cm (1.6–2.4 in) high, 8–12.5 cm (3.2–4.9 in) wide, glaucous, apical spine lacking on the lowest sporophylls, to 1–2 cm (0.4–0.8 in) long, flattened, triangular near the cone apex. Sarcotesta red, orange, or orange-brown when ripe, the exposed areas between the sporophylls turning green. Sclerotesta ovoid to long ovoid, 55–60 mm (2.2–2.4 in) long, 32–38 mm (1.3–1.5 in) in diameter, smooth. **Male cones** one to five, somewhat curved when mature, cylindrical, 25–40 cm (10–16 in) long, 8–10 cm (3.2–4 in) in diameter. Peduncle 10–14 cm (4–5.5 in) long, 4–5 cm (1.6–2 in) in diameter, surrounded by several spinelike cataphylls. Sporophylls 3–4 cm (1.2–1.6 in) long. Sporophyll face 1.5–2 cm (0.6–0.8 in) wide, about 1 cm (0.4 in) high, glaucous, basal sporophylls without spines, apical ones with spines 1.5–2.5 cm (0.6–1 in) long. **Habitat:** Desert, usually in somewhat shaded gullies or deep canyons where ground water may be present, in association with *Eucalyptus,* rarely *Livistona,* or on bare, rocky slopes with low-growing shrubs. Rainfall is generally less than 300 mm (12 in) annually and is sporadic. Summer day temperatures average 36°C (97°F), nights 21°C (70°F), and winter temperatures range from highs of 19°C (66°F) to lows of 0°C (32°F). **Distribution:** Australia, central portion of the Northern Territory, Macdonnell Ranges and Harts Range.

Macrozamia macdonnellii is a desert plant and has adapted well to its environment. The thick trunk, leaves with a strong glaucous coating, and stomata on both upper and lower surfaces tend to protect it from water loss or sunburn. *Macrozamia macdonnellii* has massive female cones, sometimes weighing as much as 20 kg (44 pounds) and producing huge seeds capable of supporting the seedling through its first year in the arid habitat. All other macrozamias are restricted to the coastal areas. *Macrozamia macdonnellii* is the only cycad to be found in the central Australian desert.

Clearly, the closest relatives of *Macrozamia macdonnellii* are *M. dyeri, M. fraseri,* and *M. riedlei* of Western Australia, which also grow in a somewhat arid habitat and have glaucous foliage and large seeds, about half the volume of those of *M. macdonnellii.* A large distance of extremely arid country separates these three species from *M. macdonnellii,* however. *Macrozamia macdonnellii* can be easily distinguished from its relatives by its strong blue color and its large seeds and female cones.

In habitat, *Macrozamia macdonnellii* exhibits a slow rate of regeneration, but the colonies are relatively stable and no major enemies are known, except humans. Seed production is generally limited with only a few cones in evidence each year. On occasion, once every few years, large numbers of female cones are produced that generate thousands of viable seeds. It is not known exactly what triggers these prolific coning events, but it may well be periods of more rainfall. The seeds remain viable for many months, as long as 3 years or more, and when finally provided with sufficient rainfall will quickly germinate. Usually, the seedling leaf is slow to appear as the plant first develops a long taproot. This primary root development is another safeguard against a dry and hostile habitat.

In cultivation, *Macrozamia macdonnellii* develops quite rapidly. The seedlings can accept large quantities of water without ill effects, as long as the soil is well drained, and fertilizer is also welcomed. It appears that the transition from desert to garden conditions is made without incident. Large specimens may be transplanted with ease and grow rapidly. *Macrozamia macdonnellii* is a massive and handsome plant, both in its habitat and in cultivation. Its size and beautiful blue-gray color should make it a welcome addition to any landscape.

The conservation status of *Macrozamia macdonnellii* appears to be safe, at least for the present. A great deal of its habitat lies within national parks and on Aboriginal land, affording protection to these cycads. The remaining habitat is generally in remote areas of difficult access. Seedling regeneration in habitat is acceptable, considering the slow growth and great age attained by these cycads. It does not appear that *M. macdonnellii* is threatened.

Macrozamia miquelii (F. Mueller) A. de Candolle 1868

PLATES 394, 395

Encephalartos miquelii F. Mueller 1862
Encephalartos spiralis var. *major* Miquel 1863
Macrozamia macleayi Miquel 1868
Macrozamia tridentata Regel 1876a
Macrozamia tridentata var. *oblongifolia* Regel 1876b, *M. tridentata* f. *oblongifolia* (Regel) J. Schuster 1932
Macrozamia mackenzii hort. ex Masters 1877, *M. tridentata* var. *mackenzii* (hort. ex Masters) J. Schuster 1932
Macrozamia cylindrica C. Moore 1884, *M. tridentata* subsp. *cylindrica* (C. Moore) J. Schuster 1932, *M. spiralis* var. *cylindrica* (C. Moore) Maiden & Betche 1916
Macrozamia tridentata f. *milkaui* J. Schuster 1932

Macrozamia miquelii, named in honor of Friedrich Anton Wilhelm Miquel (1811–1871), Dutch botanist who served as director of the Rotterdam Botanical Gardens, 1835–1846, and the Amsterdam Botanical Gardens, 1846–1859, is called zamia bush. STEMS mostly subterranean, rarely forming an aboveground stem, 0.5–1 m (1.6–3.3 ft) tall, 30–40 cm (12–16 in) in diameter. LEAVES usually 30–80, erect, then spreading, very glossy deep green, in mature plants 0.8–2.1 m (2.6–6.9 ft) long, 25–50 cm (10–20 in) wide. Petiole 12–60 cm (4.7–24 in) long. Rachis not twisted, flattened, 7–18 mm (0.3–0.7 in) broad at the lowest leaflets. Leaflets in 35–80 pairs, spreading, forwardly directed, crowded in the upper portion of the leaf and separated in the lower, open and loose, thin and flexible, lower leaflets reduced to spines, median leaflets linear, more or less straight, 17–40 cm (6.7–16 in) long, 6–11 mm (0.2–0.4 in) wide, with a pale yellow or reddish callus at the attachment, glossy above, paler below, margin entire and flat. FEMALE CONES usually solitary but sometimes two, rarely as many as four, ovoid cylindrical, 20–40 cm (8–16 in) long, 7–13 cm (2.8–5.1 in) in diameter. Peduncle 20–45 cm (8–18 in) long, 2–3 cm (0.8–1.2 in) in diameter. Sporophyll face 1.5–3 cm (0.6–1.2 in) high, 2.5–6 cm (1–2.4 in) wide, somewhat glaucous, apical spine flattened, erect, shortest to 5 mm (0.2 in) at the cone base, longest 20–35 mm (0.8–1.4 in) at the apex, 5–10 mm (0.2–0.4 in) wide at its base. Sarcotesta orange-red when ripe. Sclerotesta 23–35 mm (0.9–1.4 in) long, 18–25 mm (0.7–1 in) in diameter, the surface smooth except for 10–12 shallow, indistinct longitudinal grooves. MALE CONES usually one to several, cylindrical, 15–35 cm (6–14 in) long, 4–6.5 cm (1.6–2.6 in) in diameter. Peduncle 20–30 cm (8–12 in) long, base surrounded by several spine-like cataphylls to 15 cm (6 in) long. Sporophyll face 15–28 mm (0.6–1.1 in) high, 10–18 mm (0.4–0.7 in) wide, apical spine slender, slightly flattened, upturned 1–25 mm (to 1 in) long, longest at the cone apex. HABITAT: Wet sclerophyll forest or rain forest with stony or sandy soils, from sea level to 500 m (1600 ft). Rainfall averages 900–1350 mm (35–53 in) annually. Temperatures are in the range 22–32°C (72–90°F) in summer, 10–24°C (50–75°F) in winter. DISTRIBUTION: Australia, New South Wales, known only from the area between the upper Richmond and Clarence Rivers; Queensland, mainly in coastal areas from Rockhampton in the north, south to the border with New South Wales.

The taxonomic history of *Macrozamia miquelii* has been one of the most confused for cycads. In 1959 Lawrence A. S. Johnson cleared up most of the confusion in the classification of *Macrozamia.* The lack of sufficient data and Johnson's broad concept of species such as *M. miquelii* led him to place *M. douglasii,* a large luxuriant cycad from Frasier Island, Queensland, and *M. mountperriensis,* a smaller cycad from a drier inland area near Mount Perry, Queensland, into synonymy. Those two species have been reinstated by David L. Jones (1991, 1993), following investigation of the plants in habitat. I am in complete agreement with this change. From this same complex of plants, *M. cardiacensis* and *M. longispina* have also been described.

Macrozamia miquelii is a very decorative, medium to large cycad. It does well in cultivation and should be used more in landscaping. Its resemblance to *M. communis* has caused considerable confusion in the past as well as more recently. The two species can usually be easily distinguished by noting that *M. miquelii* has light green, more slender, flexible, and glossy leaflets. In *M. communis* the leaflet surface is dull dark green, and the leaflets are broader and not as flexible.

Macrozamia miquelii is locally common in its range and colonies of many thousands of plants can be found in undisturbed areas. Regeneration is good, and a copious amount of viable seed is produced annually in most areas. Because of its wide distribution, large colonies, and prolific regeneration, this cycad is not considered threatened.

Macrozamia montana K. D. Hill in Hill et al. 1998

The epithet for *Macrozamia montana* is derived from *montanus,* Latin and meaning growing on mountains, referring to this cycad's habitat. STEMS subterranean or above ground to 60 cm (24 in) long, 25–45 cm (10–18 in) in diameter. LEAVES usually 20–70, semiglossy to very glossy, deep green, lighter below, 1–2 m (3.3–6.6 ft) long, flat. Petiole 6–15 cm (2.4–5.9 in) long, 1–2 cm (0.4–0.8 in) wide at the lowest leaflets. Rachis not twisted. Leaflets in 35–70 pairs, basal leaflets reduced to spines, median leaflets 20–35 cm (8–14 in) long, 7–10 mm (0.3–0.4 in) wide, much lighter below than above, with an apical spine, margin flat and entire. FEMALE CONES ovoid, 24–34 cm (9.4–13 in) long, 12–14 cm (4.7–5.5 in) in diameter. Sporophyll face 2.5–4 cm (1–1.6 in) high, 4.5–7 cm (1.8–2.8 in) wide, apical spine 2–11 cm (0.8–4.3 in) long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta ovoid to oblong, 33–42 mm (1.3–1.7 in) long, 25–30 mm (1–1.2 in) in diameter. MALE CONES spindle shaped, 35–40 cm (14–16 in) long, 6–8 cm (2.4–3.2 in) in diameter. Sporophylls 23–27 mm (0.9–1.1 in) long, 22–26 mm (0.9–1 in) wide, apical spine 5–60 mm (0.2–2.4 in) long, longest at the cone apex. HABITAT: Mountain ridges in wet sclerophyll forest composed mainly of *Eucalyptus.* DISTRIBUTION: Australia, New South Wales, in the catchments of the Macleay and Manning Rivers.

Macrozamia montana is most closely related to *M. communis,* from which it differs by its glossier leaves, with shorter, broader petioles, and greater number of basal leaflets reduced and spinelike. The cones of *M. montana* have longer apical spines than those of *M. communis.* The habitats of the two species are also different with *M. montana* restricted to inland mountains and the eastern escarpment of the Northern Tablelands, and *M. communis* at lower elevations close to the coast.

I am not aware of many specimens of *Macrozamia montana* in cultivation. Its cultivation should not be different from that of *M. communis,* except that it may be more cold hardy.

The conservation status of *Macrozamia montana* seems secure. It is locally abundant within its range, and regeneration is reported as being prolific. This species may be classified as not threatened.

Macrozamia moorei F. Mueller 1881a

PAGES 2–3, PLATES 396, 397

Encephalartos moorei (F. Mueller) F. Mueller 1881b

Macrozamia moorei is named in honor of Charles Moore (1820–1905), botanist and plant collector who was also the director of the Royal Botanic Gardens, Sydney, Australia, 1848–1896. STEMS arborescent, erect, to 10 m (33 ft) tall but usually 3–4 m (10–13 ft) tall, 60–80 cm (24–32 in) in diameter. LEAVES 50–150, strongly arching, at first erect, then spreading, finally drooping, slightly keeled. Petiole somewhat four-angled, 2.5–5 cm (1–2 in) long. Rachis not twisted. Leaflets generally equally drawn out, directed forward at an acute angle, with a flexible pungent apex, gradually reduced in length until almost spinelike in the lower third of the leaf, median leaflets 20–30 cm (8–12 in) long, 1–1.4 cm (0.4–0.6 in) wide, with a slightly swollen whitish callus where attached to the rachis, margin flat and entire. FEMALE CONES one to eight, erect, short cylindrical, 45–80 cm (18–32 in) long, 15–20 cm (6–8 in) in diameter, slightly glaucous. Peduncle 14–23 cm (5.5–9 in) long, 45–58 mm (1.8–2.3 in) in diameter, glaucous. Sporophylls 5–7 cm (2–2.8 in) long. Sporophyll face 2–3 cm (0.8–1.2 in) high, 4–8 cm (1.6–3.2 in) wide, apical spine flattened, erect, shortest to 8 mm (0.3 in) long at the cone base, longest 25–70 mm (1–2.8 in) long at the apex. Sarcotesta deep red when ripe. Sclerotesta irregularly shaped, 4–4.5 cm (1.6–1.8 in) long, 3 cm (1.2 in) in diameter, smooth. MALE CONES 15–20 in mature plants, cylindrical, 45–53 cm (18–21 in) long, 75–88 mm (3–3.5 in) in diameter, narrowing toward apex and base. Peduncle 10–15 cm (4–6 in) long, 27 mm (1.1 in) in diameter, glaucous, glabrous. Sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 14 mm (0.6 in) high, 15–20 mm (0.6–0.8 in) wide, lightly sprinkled with brown scales mainly on the spine and spine blade, apical spine to 2 cm (0.8 in) long, longest at the cone apex. Sporangia in a single patch. HABITAT: Dry sclerophyll forest on rocky soils, preferring steep slopes and the margins of rivers, at elevations averaging about 430 m (1400 ft). Rainfall averages 635 mm (25 in) annually. The average daily maximum temperature in the warmest month is 34°C (93°F), the average minimum in the coldest 6°C (43°F). Frosts occur June–August. DISTRIBUTION: Australia, Queensland, from between Emerald and Springsure in the north to Injune in the south, with a large concentration in Carnarvon Gorge.

Although Ferdinand von Mueller described *Macrozamia moorei* in 1881, it was originally observed by a European decades earlier. The first recorded sighting was by the German explorer Friedrich Wilhelm Ludwig Leichhardt during his traverse of the Australian continent in 1844–1845. Leichhardt published his journal of this trip in 1847, from which the following excerpt is taken:

> The most remarkable feature in the vegetation, however, was an arborescent *Zamia*, with a stem from seven to eight or ten feet [2.1–3 m] high, and about nine inches [23 cm] in diameter, and with elongated cones not yet ripe. In consequence of the prevalence of this plant, I called the creek "Zamia Creek."

The creek referred to by Leichhardt is still known as Zamia Creek and is located in a remote area north of Taroom in central Queensland.

Macrozamia moorei is not uncommon in public and private collections, no doubt the result of its great numbers in habitat and copious seed production. Viable seed is the rule rather than the exception, and it is easily germinated and grown. The growth rate is rapid, and handsome plants can be produced in a few years. Cold tolerance is very good and short periods of freezing do not affect this species. As an ornamental, *M. moorei* is difficult to surpass with its multitude of gray-green arching leaves. This cycad is at home in either full sun or light shade. The only limiting factor for ornamental use is this cycad's large size, because a mature plant will have a leaf spread of 5 m (16 ft) or more. The size limits its use in average home gardens, but as a landscape feature in larger plantings it is exceptional. Each of its long, flexible leaflets is tipped with a sharp spine, and this must be taken into consideration when using this cycad close to areas with foot traffic where it might cause injury.

In my opinion, *Macrozamia moorei* is the most beautiful and majestic of all the species of the genus. When seen in its native haunts, *M. moorei* is unforgettable. This majestic cycad is sometimes mistaken for the date palm, *Phoenix dactylifera,* because of the glaucous green leaves and large size. In many parts of its habitat it occurs in large colonies and is a major feature of the landscape. These localities take on an unreal prehistoric air, and one almost expects to see dinosaurs wandering through.

Macrozamia moorei occurs in cattle country and because of their poisonous qualities many thousands of the plants have been destroyed. Cattle feeding on the leaves are affected by the toxin they contain and develop what the ranchers refer to as rickets. The toxin causes a paralysis of the rear quarters, making movement almost impossible, and the cattle die of thirst and hunger rather than the direct results of the poison. In the past, the Australian government distributed flyers giving directions as to how the cycads could be killed.

Yet the conservation status of *Macrozamia moorei* is still sound. There are many large colonies, most producing seed in large quantities. Seedling regeneration is good, to a point where some colonies are enlarging. Ranchers in areas where *M. moorei* occurs in large colonies have fenced them off rather than try to destroy them. This is usually not in the interest of conservation but because it is the most cost effective way to protect their cattle. Whatever the reason, it is a positive step in conserving one of Australia's most beautiful and majestic cycads.

Macrozamia mountperriensis F. M. Bailey 1886

PLATES 398, 399

Macrozamia tridentata subsp. *mountperriensis* (F. M. Bailey) J. Schuster 1932

The epithet for *Macrozamia mountperriensis* refers to the town of Mount Perry, Queensland, Australia, where this cycad was first found. **Stems** subterranean or rarely with 15–22.5 cm (6–8.9 in) of the stem above ground, mature plants usually no more than 22.5 cm (8.9 in) in diameter. **Leaves** 20–80 in an average crown, very glossy deep green, erect, straight to slightly arching, 0.9–1.8 m (3–5.9 ft) long, 60–75 cm (24–30 in) wide. Petiole unarmed, 30–45 cm (12–18 in) long, somewhat angular, its base swollen and densely brown tomentose. Leaflets in 25–50 pairs, linear lanceolate, gradually acuminate, pungent, shortest at the leaf apex, lower leaflets usually not reduced in length and not reduced to spines, median leaflets 24–35 cm (9.4–14 in) long, 6–9 mm (0.2–0.4 in) wide, with 10–12 prominent veins on the lower surface and a prominent white to cream callus at the attachment to the rachis, margin flat and entire. **Female cones** solitary, at first upright, leaning at maturity, cylindrical, 18–30 cm (7.1–12 in) long, 8.8–10 cm (3.5–4 in) in diameter, bright green. Peduncle 20–30 cm (8–12 in) long, about 1.5 cm (0.6 in) in diameter, glabrous. Sporophyll face 1.5–2.5 cm (0.6–1 in) high, 3.5–4 cm (1.4–1.6 in) wide, with a prominent transverse ridge forming at its center an upright, flat, linear lanceolate spine 6–35 mm (0.2–1.4 in) long, longest at the cone apex. Sarcotesta deep orange-red when ripe, rarely yellow. Sclerotesta 18–27 mm (0.7–1.1 in) long, 16–20 mm (0.6–0.8 in) in diameter, light brown, with about 12 shallow longitudinal grooves and a fine network of shallow fissures over the entire surface, with four or five flattened areas. **Male cones** solitary or sometimes two to four, cylindrical, 15–23 cm (6–9.1 in) long, 30–38 mm (1.2–1.5 in) in diameter, green. Peduncle 12–20 cm (4.7–8 in) long, 1–1.5 cm (0.4–0.6 in) in diameter. Sporophyll face 8–14 mm (0.3–0.6 in) high, 12–25 mm (0.5–1 in) wide, with a transverse ridge forming an upright flat spine at its center, spine very short at the base of the cone, becoming longer toward the apex, to 15 mm (0.6 in). Sporangia in a single patch. **Habitat:** Grassy hillsides and ridges in open *Eucalyptus* forest, or in vine forests to rain forests, in soils that are rocky and generally shallow. Rainfall averages about 1000 mm (40 in) annually, falling mainly in summer. The climate is subtropical, with hot, wet summers and cool to cold winters with frequent frosts. **Distribution:** Australia, Queensland, in the region of Mount Perry, with scattered colonies as far south as Biggenden, as far east as Aramara.

When Frederick Manson Bailey described *Macrozamia mountperriensis* in 1886, he felt it was distinct from its closest relative, *M. miquelii,* because of its smaller size and the absence of reduced leaflets and spines on the petiole. In 1959 Lawrence A. S. Johnson revised *Macrozamia* and saw fit to place *M. mountperriensis* into synonymy under *M. miquelii,* a determination made largely on the basis of herbarium specimens, without studying the populations in their habitat. In 1991 David L. Jones elevated it once again to the rank of species because of the differences between it and *M. miquelii.* Besides those features noted by Bailey, *M. mountperriensis* differs from *M. miquelii* in having smaller cones and seeds.

Macrozamia mountperriensis takes well to cultivation and presents no problems in the garden or as a container plant. As with most macrozamias, *M. mountperriensis* prefers a garden situation with sufficient moisture and well-drained soil. With proper care it will form an attractive plant in a short time. In common with other macrozamias, this species displays a high degree of cold tolerance and several degrees of frost will not cause any apparent damage. In cultivation a somewhat shaded location leads to superior development of the arching, glossy leaves.

The conservation status of *Macrozamia mountperriensis* is secure. There are numerous large colonies, producing abundant seed crops, and regeneration in habitat is good. Land clearance has not yet posed a problem for the survival of this species, but that could change. *Macrozamia mountperriensis* is not considered threatened.

Macrozamia occidua D. L. Jones & P. I. Forster in Forster & Jones 1994

PLATE 400

The epithet for *Macrozamia occidua* is derived from *occiduus,* Latin and meaning going down, setting, referring to Sundown National Park, Queensland, Australia, where this cycad occurs. **Stems** subterranean, unbranched, more or less ovoid, 10–20 cm (4–8 in) in diameter. **Leaves** usually one to five, erect, semiglossy, dark green to gray-green, spirally twisted two to four times, 40–75 cm (16–30 in) long, moderately keeled, base densely covered with fawn to gray-green tomentum. Petiole flat above, strongly convex below, dark green, 10–25 cm (4–10 in) long, 6–10 mm (0.2–0.4 in) in diameter at the lowest leaflet. Leaflets in 40–60 pairs, linear, angled forward about 60°, obliquely erect to spreading, longest at the center of the leaf, becoming shorter toward both apex and base, basal leaflets not reduced to spines, median leaflets 6–20 cm (2.4–7.9 in) long, 3–10 mm (to 0.4 in) wide, dark green above, glaucous below, not twisted except at the base, crowded, spaced 3–24 mm (to 0.9 in) apart, the upper surface concave in cross section, apex acuminate, sometimes two- or three-toothed, the callous base greenish yellow, rarely pink, margin flat or curved slightly inward. **Female cones** solitary, ovoid, 10–14 cm (4–5.5 in) long, 5–8 cm (2–3.2 in) in diameter, glaucous. Peduncle furrowed, 6–16 cm (2.4–6.3 in) long, 12–16 mm (0.5–0.6 in) in diameter, round to elliptical in cross section. Sporophylls 2–2.5 cm (0.8–1 in) long. Sporophyll face transversely elliptical to transversely ovate, 10–13 mm (0.4–0.5 in) high, 20–30 mm (0.8–1.2 in) wide, with a sunken area just below the apical spine, apical spine 3–20 mm (to 0.8 in) long, longest at the cone apex. Sarcotesta orange to red when ripe. Sclerotesta ovoid, 18–25 mm (0.7–1 in) long, 15–22 mm (0.6–0.9 in) in diameter. **Male cones** solitary, erect, more or less cylindrical, 10–24 cm (4–9.4 in) long, 3.5–5 cm (1.4–2 in) in diameter, glaucous. Peduncle 8–15 cm (3.2–6 in) long, 16–20 mm (0.6–0.8 in) in diameter, round in cross section, smooth to irregularly furrowed. Sporophylls 1.5–2.5 cm (0.6–1 in) long. Sporophyll face 10–17 mm (0.4–0.7 in) wide, most sporophylls with vestigial apical spine, apical spine stiff, pointed, to 5 mm (0.2 in) long at the apex. Sporangia in a single patch on basal sporophylls, in two patches on apical ones. **Habitat:** Sandy soil in open forest dominated by *Eucalyptus prava* and *E. sideroxylon.* **Distribution:** Australia, extreme southern Queensland in the Darling Downs district near the New South Wales border, the two known populations in Sundown National Park.

When *Macrozamia occidua* was discovered it was mistakenly identified as *M. plurinervia.* Additional field studies proved it to be undescribed. Its closest relative is *M. cranei,* but it differs from that species in its shorter leaves, shorter dull leaflets, and glaucous cones.

Macrozamia occidua is an interesting rather than a beautiful cycad. In its habitat it blends into the low shrubs and grasses and can be quite easily overlooked. In cultivation, plants may develop into more handsome specimens. I assume that plants will be slow growing, as true of most dwarf macrozamias. This species should be sun tolerant and frost resistant.

The two populations of *Macrozamia occidua* are located in Sundown National Park, which affords them some protection. The populations are small, and some poaching has taken place. It is hoped that sufficient protection will be given to this species to assure its continued survival in the wild. *Macrozamia occidua* must be considered threatened.

Macrozamia parcifolia P. I. Forster & D. L. Jones 1994

PLATE 401

The epithet for *Macrozamia parcifolia* is derived from *parcus,* Latin for frugal, scanty, thrifty, and *folium,* leaf, referring to the slender, wispy leaflets of this cycad. **Stems** subterranean, usually unbranched, more or less ovoid, 10–20 cm (4–8 in) in diameter. **Leaves** usually one to four, erect, spirally twisted two to six times, very glossy dark green, 65–95 cm (26–37 in) long. Petiole dark dull green, slightly concave above, strongly convex below, 15–30 cm (6–12 in) long, 6–9 mm (0.2–0.4 in) in diameter at the lowest leaflet. Leaflets in 50–110 pairs, very narrowly linear, angled forward about 30°, obliquely erect to curved or bowed, drooping in the apical third to half, the surface dark green above, the upper surface strongly concave in cross section, bright green below, thin textured, spirally twisted one to three times, not crowded, spaced 5–25 mm (0.2–1 in) apart, the longest leaflets toward the middle of the leaf, reduced in length toward the base and apex, apex acuminate, the callous base greenish white and obscure, basal leaflets not reduced to spines, median leaflets 15–40 cm (6–16 in) long, 1–3 mm wide, margins flat and entire. **Female cones** solitary, erect, ovoid to ovoid cylindrical, 8–14 cm (3.2–5.5 in) long, 4–6 cm (1.6–2.4 in) in diameter. Peduncle 13–18 cm (5.1–7.1 in) long, 6–10 mm (0.2–0.4 in) in diameter, elliptical in cross section, smooth. Sporophylls 1.5–2 cm (0.6–0.8 in) long. Sporophyll face transversely ovate, 10–14 mm (0.4–0.6 in) high, 20–27 mm (0.8–1.1 in) wide, with a prominent depression just below the apical spine, apical spine to 28 mm (1.1 in) long, longest at the cone apex. Sarcotesta orange to red when ripe. Sclerotesta irregularly globose to ovoid, 17–25 mm (0.7–1 in) long, 15–20 mm (0.6–0.8 in) in diameter, the surface with 11–13 indistinct longitudinal grooves. Chalaza with a pit 2–3 mm in diameter. **Male cones** solitary, erect, more or less cylindrical 7–14 cm (2.8–5.5 in) long, 2.5–4 cm (1–1.6 in) in diameter. Peduncle 6–12 cm (2.4–4.7 in) long, 6–12 mm (0.2–0.5 in) in diameter, elliptical in cross section. Sporophylls 12–18 mm (0.5–0.7 in) long. Sporophyll face 6–8 mm (0.2–0.3 in) high, 12–17 mm (0.5–0.7 in) wide. Sporangia in two patches on sporophylls in the basal cone area, in a single patch in the apical area. **Habitat:** Understory on ridges and in tall open forest dominated by *Eucalyptus citriodora* and *E. fibrosa,* in hard, red-brown clay loams of basaltic origin, at elevations of 180–220 m (590–720 ft). **Distribution:** Australia, southeastern coastal Queensland, Wide Bay district near Seaview Range and Biggenden.

Macrozamia parcifolia is an interesting species of section *Parazamia.* This cycad is notable for having the narrowest leaflets of any of the macrozamias. It is closely related to *M. pauli-guilielmi,* which also has very narrow leaflets and is found somewhat farther south along the coast of Queensland at Tin Can Bay. *Macrozamia parcifolia* can be distinguished from *M. pauli-guilielmi* by its narrower, thinner textured, darker green leaflets, which are inserted into the rachis at a steeper angle. Additionally, the callous base of its leaflets is greenish white and obscure in comparison to the prominent cream to white callous base of *M. pauli-guilielmi.* The fineness of its leaves makes *M. parcifolia* very difficult to find among the grasses native to its habitat.

The growth rate of *Macrozamia parcifolia* is doubtless as slow as other species of section *Parazamia* and for this reason it would not be of nursery interest. The very fine leaflets, however, make this a species of interest to collectors. In the 4 years I have grown *M. parcifolia* from seed it has shown a surprisingly rapid growth rate, and there is the possibility that it will grow better in cultivation than it does in the wild. Sun and frost tolerance appear to be good, judging by the scant experience I have had with *M. parcifolia* thus far. This cycad will no doubt develop into a fine plant for small gardens and for growing in pots.

The conservation status of *Macrozamia parcifolia* seems reasonably secure even though only two populations are known. The Biggenden population is mainly within Mount Walsh National Park, and the Seaview Range one occurs in state forest. Illegal collecting from these small populations could quickly place this species in jeopardy, and for this reason *M. parcifolia* must be considered threatened.

Macrozamia pauli-guilielmi W. Hill & F. Mueller 1859

PLATES 402, 403

Macrozamia plumosa hort. ex Masters 1875

Macrozamia pauli-guilielmi is named in honor of Prince Paul William of Württemberg. **Stems** subterranean or as much as 10–15 cm (4–6 in) above ground, ovoid, 10–25 cm (4–10 in) in diameter, and covered by an armor of densely woolly leaf bases. **Leaves** usually 2–10, at first erect, then spreading, twisted through at least two complete revolutions, thus very plumelike in appearance, 0.6–1.1 m (2–3.6 ft) long, 25–55 cm (10–22 in) wide. Petiole flat above, slightly rounded below, 5–10 cm (2–3.9 in) long, 7–11 mm (0.3–0.4 in) wide. Leaflets in 70–100 pairs, crowded, very narrow, the upper surface concave in cross section, median leaflets 15–30 cm (6–12 in) long, 2–4 mm wide, the callus at the attachment whitish to cream. **Female cones** usually solitary, erect, cylindrical, 10–25 cm (4–10 in) long, 7–9 cm (2.8–3.5 in) in diameter, light green. Peduncle 12–20 cm (4.7–8 in) long, 18–30 mm (0.7–1.2 in) in diameter. Sporophyll face 1.5–3 cm (0.6–1.2 in) high, 3.5–6 cm (1.4–2.4 in) wide, somewhat glaucous, apical spine spreading, sometimes curved backward and downward at its apex, 2–25 mm (to 1 in) long, longest at the cone apex. Sarcotesta orange to scarlet when ripe. Sclerotesta irregularly globose, 21–24 mm (0.8–0.9 in) long, 15–20 mm (0.6–0.8 in) in diameter, light tan, with 12–16 faint longitudinal grooves. **Male cones** usually one to three, erect, cylindrical, 8–25 cm (3.2–10 in) long, 4–6 cm (1.6–2.4 in) in diameter, lime green. Peduncle 5–8 cm (2–3.2 in) long, 1.5 cm (0.6 in) in diameter, furrowed. Sporophylls 14–18 mm (0.6–0.7 in) long. Sporophyll face wedge shaped, 13–20 mm (0.5–0.8 in) high, 15–23 mm (0.6–0.9 in) wide, apical spine erect, 1–5 mm (to 0.2 in) long, longest at the cone apex. Sporangia in two patches, covering the undersurface of the sporophyll except for a narrow sterile margin at the sides. **Habitat:** Stabilized sand in coastal areas, usually under *Eucalyptus* cover, from almost sea level to 25 m (82 ft). Rainfall averages 1500–1800 mm (59–71 in) annually, falling mainly in summer. Temperatures range from a high of 32°C (90°F) in summer to a low of –2°C (28°F) in winter. **Distribution:** Australia, southeastern Queensland, area around Gympie and Tin Can Bay, and Fraser Island.

Macrozamia pauli-guilielmi was described in 1859 by Walter Hill and Ferdinand von Mueller from specimens collected at Moreton Bay, Queensland. A century later, Lawrence A. S. Johnson (1959) recognized a complex of three subspecies of *M. pauli-guilielmi*: *pauli-guilielmi, flexuosa,* and *plurinervia,* based on the concept that the three populations intergraded with each other over their distributional range. Later field studies disclosed that there was no intergrading and that the colonies were completely isolated from each other. With this new information, David L. Jones (1991) recognized the taxa as distinct species.

Macrozamia pauli-guilielmi is one of the most distinctive species of section *Parazamia.* The very narrow leaflets form a plumelike leaf because of the usually two to five complete twists in the rachis. The white to cream callus at the base of each leaflet adds a subtle touch to the overall appearance. The nearest relative of *M. pauli-guilielmi* is *M. parcifolia,* which can be distinguished by its thinner textured dark green leaves and narrower leaflets.

Macrozamia pauli-guilielmi is not often found in collections, maybe because it has been almost eradicated from its habitat. Where once it was common it is now quite scarce and threatened by coastal development, agriculture, and planting of pine plantations. *Macrozamia pauli-guilielmi* makes a fine pot plant and conversation piece for any patio. It is easy to grow and will become quite lush with regular applications of fertilizer during the growing season.

The conservation status of *Macrozamia pauli-guilielmi* is clearly not secure. It occurs mainly in areas used for pastures and agriculture, and great numbers of this species have been destroyed to protect stock or in the clearance of land to plant crops such as pineapples. More recently, many plants have been removed from habitat for collectors or general garden use. As far as I am aware, it does not occur on any protected land. For these reasons, *M. pauli-guilielmi* must be considered endangered.

Macrozamia platyrachis F. M. Bailey 1898

PLATE 404

The epithet for *Macrozamia platyrachis* is derived from *platys,* Greek for broad, and *rachis,* midrib, referring to the broad, flat rachis of the leaf. **Stems** subterranean, 10–25 cm (4–10 in) in diameter, crown, cataphylls, and leaf bases generally lacking tomentum. **Leaves** seldom more than eight, 50–80 cm (20–32 in) long, 40–60 cm (16–24 in) wide. Petiole 15–25 cm (6–10 in) long, 13–18 mm (0.5–0.7 in) in diameter, base without tomentum. Rachis not twisted or only very slightly so, curved backward and downward, flattened above, convex or angular below. Leaflets in 15–25 pairs, spreading, erect, angled forward and twisted at the base, not crowded, stiff and leathery, entire, straight to curved backward and downward, falcate, broad linear, lower leaflets slightly reduced in size but not to spines, median leaflets 30–40 cm (12–16 in) long, 1.2–2 cm (0.5–0.8 in) wide, slightly tapered, abruptly rounded at the apex, which is mucronate or rarely serrulate with two to six fine teeth, narrowed toward the pale, decurrent, but not callous base, green and slightly glossy above, much lighter below than above, with stomata confined to the lower surface. **Female cones** solitary, ovoid cylindrical, 15–20 cm (6–8 in) long, 8–10 cm (3.2–4 in) in diameter. Peduncle 7–12 cm (2.8–4.7 in) long, 13–20 mm (0.5–0.8 in) in diameter. Sporophyll face 2–3 cm (0.8–1.2 in) high, 4–5 cm (1.6–2 in) wide, apical spine erect, flattened, 3–13 mm (to 0.5 in) long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta irregularly globose, 23–25 mm (0.9–1 in) long, 20–24 mm (0.8–0.9 in) in diameter, the surface with numerous shallow, indistinct, longitudinal grooves. **Male cones** usually solitary, rarely two or three, cylindrical, 15–25 cm (6–10 in) long, 42–55 mm (1.6–2.2 in) in diameter. Peduncle 17.5–22 cm (7–8.7 in) long, 17–20 mm (0.7–0.8 in) in diameter. Sporophylls 18–21 mm (0.7–0.8 in) long. Sporophyll face 8–10 mm (0.3–0.4 in) high, 16–19 mm (0.6–0.7 in) wide, apical spine erect, to 8 mm (0.3 in) long, longest at the cone apex, slender. **Habitat:** Dry areas at elevations of 500–1000 m (1600–3300 ft), in sandy soils in open forest, often in association with *Livistona* and *Xanthorrhoea.* Rainfall is 800–1000 mm (32–39 in) annually, falling mostly in summer. Summers are hot with day temperatures rising to 38°C (100°F), dropping at night to about 24°C (75°F), and winters generally reaching a maximum of 25°C (77°F) in the day, with lows of about 8°C (46°F) at night, with frosts relatively common in some areas. **Distribution:** Australia, central western Queensland, from the Blackdown Tablelands south to Planet Downs station.

Macrozamia platyrachis was described in 1898, based on specimens collected from Planet Downs station in central western Queensland. It is one of the rarest and most distinctive cycads of section *Parazamia.* The long, broad leaflets, leaves curved strongly backward and downward, and wide rachis, which is flat above and angular below, make this species easily recognizable. It is the northernmost member of the section.

Macrozamia platyrachis is a unique little cycad that is easy to grow but not often found in collections because of its rarity. But numerous plants are being grown from seed, which germinates easily and the plants grow steadily if not rapidly. Even as a seedling, this cycad is distinctive and decorative. Seed production in habitat is not dependable and appears to be cyclic with coning events taking place every 4–7 years. The number of seeds per cone is small with the average cone holding only 10–25. This scarcity of seed drastically limits the number of seedlings that can be produced any given year.

The conservation status of *Macrozamia platyrachis* is not good. The distribution of *M. platyrachis* is roughly from Planet Downs station and Rolleston in the south to Blackdown Tablelands National Park in the north. This cycad is one of the most limited in range and number in the wild. Regeneration from seed is very limited in all of the known localities as a result of its sporadic coning cycles. For these reasons, *M. platyrachis* must be considered threatened and should be provided whatever protection is necessary for its survival.

Macrozamia plurinervia (L. A. S. Johnson) D. L. Jones 1991

PLATE 405

Macrozamia pauli-guilielmi subsp. *plurinervia* L. A. S. Johnson 1959

Macrozamia plurinervia, the epithet derived from *pluri-,* Latin for several, and *-nervius,* nerved, referring to the wide leaflets, is called blackfellow's pineapple. **Stems** usually subterranean, rarely branching, ovoid, 10–20 cm (4–8 in) in diameter, and covered by an armor of densely woolly leaf bases. **Leaves** usually one to six, erect, then spreading, 30–90 cm (12–36 in) long, 20–50 cm (8–20 in) wide. Petiole flat above, rounded below, 5–20 cm (2–7.9 in) long, 5–11 mm (0.2–0.4 in) in diameter. Rachis twisted through one to several revolutions, giving the leaf a plumelike appearance. Leaflets in 25–75 pairs, crowded to sparse, angled forward about 60°, twisted at the base so as to be facing forward, somewhat stiff, dull green above, glaucous below, the upper surface flat or slightly concave in cross section, the callous base usually orange or reddish, median leaflets 10–30 cm (4–12 in) long, 4–10 mm (to 0.4 in) wide, margin flat and entire. **Female cones** usually solitary, erect, ovoid, 10–25 cm (4–10 in) long, 7–9 cm (2.8–3.5 in) in diameter, glaucous. Peduncle 10–15 cm (4–6 in) long, 2 cm (0.8 in) in diameter. Sporophyll face 3–4 cm (1.2–1.6 in) high, 4–5.5 cm (1.6–2.2 in) wide, apical spine spreading, curved backward and downward, almost vestigial at the cone base, 1–25 mm (to 1 in) long, longest at the cone apex. Sarcotesta orange to red when ripe. Sclerotesta irregularly ovoid to globose, somewhat three-sided, 24–28 mm (1–1.1 in) long, 19–26 mm (0.8–1 in) in diameter, with 20–22 faint, irregular, longitudinal grooves. **Male cones** usually solitary, sometimes two or three, short cylindrical, 8–25 cm (3.2–10 in) long, 4–6 cm (1.6–2.4 in) in diameter, glaucous. Peduncle 2 cm (0.8 in) high, 6–10 cm (2.4–3.9 in) wide. Sporophyll face 15–18 mm (0.6–0.7 in) high, 23–35 mm (0.9–1.4 in) wide, apical spine 1–10 mm (to 0.4 in) long, vestigial at the cone base, longest at the apex. **Habitat:** Open *Eucalyptus* woodland in very stony soil at elevations of 900–1200 m (3000–3900 ft). Rainfall averages 600–800 mm (24–32 in) annually, falling mainly in spring and late summer. Temperatures range from a high of 30°C (86°F) to a low of 10°C (50°F) in summer, and from a high of 15°C (59°F) to a low of −4°C (25°F) in winter. Heavy frosts are frequent in some areas. **Distribution:** Australia, northeastern New South Wales, western slopes of the tablelands, and upper Hunter Valley, extending from Wallangarra southwest through Tingha, to the southern end of the Warrumbungle Range, and from Nundle to Coolah Tops, also reported from the valley of the Goulburn River.

In 1959 Lawrence A. S. Johnson recognized three subspecies of *Macrozamia pauli-guilielmi*: *pauli-guilielmi, flexuosa,* and *plurinervia.* In 1991 David L. Jones recognized the three at the rank of species after critically comparing them in the wild. He found that each has a specific habitat and that the three are completely isolated from each other with no intermediates. Field observations that I made in 1984 and 1986 agree with this treatment. *Macrozamia plurinervia* can be distinguished from its two closest relatives, *M. flexuosa* and *M. pauli-guilielmi,* by its glaucous cones, its broader, thicker textured, gray-green to glaucous leaflets, and its broader petiole and rachis.

Macrozamia plurinervia does not appear to be common in spite of its reported wide distribution. Like other species of section *Parazamia,* it appears to be of very localized occurrence and one can spend days looking for a colony without success. This handsome little cycad is, however, worth the effort. *Macrozamia plurinervia* grows in dry inland areas and is very drought tolerant, having adapted to the sparse and irregular rainfall. As with other cycads growing in harsh habitats, coning is erratic and cyclic, taking place about every 4–5 years.

In cultivation, *Macrozamia plurinervia* is trouble-free and undemanding. It requires well-drained soil but is tolerant of sun and frost. Its size makes it a fine pot plant, or a garden plant for small exposed areas. The distinctively twisted and somewhat glaucous leaves make it a fine addition to any collection.

There is insufficient information to assess the conservation status of *Macrozamia plurinervia.* It occurs in small, remote, and scattered colonies, which makes it difficult to conduct an accurate census. Grass and brush fires do not affect its underground stem, and if anything, seem to promote formation of new leaves and cones. Additional fieldwork is necessary to document the natural range of this cycad and its numbers properly. Because of the small size of the known colonies, this cycad must be considered extremely endangered.

Macrozamia polymorpha D. L. Jones in Hill et al. 1998

PLATE 406

The epithet for *Macrozamia polymorpha* is derived from *poly-,* Greek for many, and *morphe,* form, referring to this cycad's variability of form. **Stems** subterranean, 10–25 cm (4–10 in) in diameter. **Leaves** usually 2–11 in a crown, semiglossy bright green, curved strongly backward and downward near the apex, 0.5–1 m (1.6–3.3 ft) long, strongly to moderately keeled. Petiole 12–22 cm (4.7–8.7 in) long, 7–10 mm (0.3–0.4 in) in diameter. Rachis not twisted. Leaflets in 30–60 pairs, angled forward about 60°, crowded, those near the base more widely spaced, twisted at the base so as to be facing forward, usually entire but may be divided once or twice, lower leaflets not reduced to spines, median leaflets 10–20 cm (4–8 in) long, 3–8 mm (to 0.3 in) wide, linear, the callous base greenish cream to cream, margins flat and entire. **Female cones** generally solitary, ovoid, 13–20 cm (5.1–8 in) long, 7–9 cm (2.8–3.5 in) in diameter, green. Peduncle 12–18 cm (4.7–7.1 in) long, 18–28 mm (0.7–1.1 in) in diameter. Sporophyll face 1.5–2 cm (0.6–0.8 in) high, 4.5–5 cm (1.8–2 in) wide, apical spine 2–30 mm (to 1.2 in) long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta ovoid, 26–30 mm (1–1.2 in) long, 22–25 mm (0.9–1 in) in diameter. **Male cones** spindle shaped, 16–24 cm (6.3–10 in) long, 4.5–5.5 cm (1.8–2.2 in) in diameter. Peduncle 12–18 cm (4.7–7.1 in) long, 18–28 mm (0.7–1.1 in) in diameter. Sporophylls 16–24 mm (0.6–0.9 in) long. Sporophyll face 13–19 mm (0.5–0.8 in) wide, apical spine 2–15 mm (to 0.6 in) long, longest at the cone apex. **Habitat:** Dry sclerophyll woodlands in sandy soils over sandstone. Rainfall averages 700 mm (28 in) annually, falling mainly in summer. The climate is temperate, with hot, dry summers with highs of 32°C (90°F), lows of 15°C (59°F), and cold winters with highs of 16°C (61°F), lows of 0°C (32°F), with heavy frosts common. **Distribution:** Australia, northern New South Wales, vicinity of Coonabarabran, north to the southern Pilliga scrub.

Macrozamia polymorpha is an interesting rather than handsome cycad that belongs to the *M. heteromera* complex together with *M. glaucophylla.* It can be distinguished from *M. heteromera* by its bright green leaves, broader leaflets, usually not divided, and the undivided leaflets of seedlings, and from *M. glaucophylla* by its green rather than gray leaves, which are not so strongly keeled and curved backward and downward.

Macrozamia polymorpha presents no problems in cultivation. It is very frost hardy and grows quite well in full sun or under varying degrees of shade. This cycad grows slowly in its habitat but apparently more rapidly in cultivation. Its small size makes it a good rock garden or pot plant. In its habitat, *M. polymorpha* is burned annually by grass fires, but unlike other species of the genus, the fires do not seem to influence cone production. *Macrozamia polymorpha* cones erratically with coning usually taking place every 4–8 years.

The conservation status of *Macrozamia polymorpha* seems to be relatively secure. It grows on poor land and has a large area of distribution, and for these reasons it can be considered as not threatened.

Macrozamia reducta K. D. Hill & D. L. Jones in Hill et al. 1998

Macrozamia tridentata f. *dielsii* J. Schuster 1932
Macrozamia tridentata f. *wallsendensis* J. Schuster 1932

The epithet for *Macrozamia reducta* is derived from *reductus,* Latin for reduced and referring to this cycad's small size. Stems subterranean or rarely to 40 cm (16 in) tall, 20–40 cm (8–16 in) in diameter. Leaves usually 12–40, semiglossy, bright to medium green above, much lighter below, 0.7–1.5 m (2.3–4.9 ft) long, flat. Petiole 13–30 cm (5.1–12 in) long, 8–20 mm (0.3–0.8 in) wide. Leaflets in 37–60 pairs, basal leaflets reduced to spines, median leaflets 16–32 cm (6.3–13 in) long, 5–9 mm (0.2–0.4 in) wide, margin flat and entire, ending in an apical spine. Female cones ovoid, 16–23 cm (6.3–9.1 in) long, 9–12 cm (3.5–4.7 in) in diameter. Sporophylls 1.5–2.5 cm (0.6–1 in) high, 4–6.5 cm (1.6–2.6 in) wide, apical spine 5–70 mm (0.2–2.8 in) long, longest at the cone apex. Sarcotesta red when ripe. Sclerotesta ovoid, 24–30 mm (0.9–1.2 in) long, 20–26 mm (0.8–1 in) in diameter, tan, smooth. Male cones spindle shaped, 25–33 cm (10–13 in) long, 6.5–7.5 cm (2.6–3 in) in diameter. Sporophylls 28–33 mm (1.1–1.3 in) long, 17–22 mm (0.7–0.9 in) wide, apical spine 2–25 mm (to 1 in) long, longest at the cone apex. Habitat: Ridges in dry sclerophyll woodlands in sandy soils over sandstone. Distribution: Australia, eastern central New South Wales, from the western suburbs of Newcastle west almost to Mudgee.

Macrozamia reducta has been known by collectors for many years as the Cessnock dwarf, named after the town of Cessnock in central eastern New South Wales, Australia. It is most closely related to *M. communis,* which it resembles in many respects. It differs from *M. communis* by its smaller size, shorter leaves, and smaller female and male cones. In habitat, it does not appear as lush as *M. communis,* nor does it retain as many leaves.

Macrozamia reducta is easily grown and presents no problems as a garden plant. In fact, as a garden plant it benefits from the additional water and nutrients. The growth rate of *M. reducta* in cultivation far surpasses that in habitat. *Macrozamia reducta* is considered as not threatened because of its wide distribution and abundance in the wild.

Macrozamia riedlei (Fischer ex Gaudichaud-Beaupré) C. A. Gardner 1930

PLATE 407

Cycas riedlei Fischer ex Gaudichaud-Beaupré 1829

Macrozamia riedlei is named in honor of Anselme Riedle (1775–1801), a gardener at the Botanical Garden in Paris, France. Stems usually subterranean but sometimes emergent to a height of 24.4 cm (9.6 in), 24–40 cm (9.4–16 in) in diameter. Leaves usually 10–30, semiglossy to very glossy, bright to deep green, at first erect, later spreading and drooping, 1.2–2.2 m (3.9–7.2 ft) long, 20–30 cm (8–12 in) wide in mature plants, slightly keeled to flat. Petiole 18–50 cm (7.1–20 in) long, flat above except for a central ridge, convex and angular below with a swollen tomentose base. Rachis not twisted, flat above, more or less convex to angular below. Leaflets in 46–75 pairs, set slightly keeled on the rachis, dull green above, lighter below, angled forward about 40°, crowded toward the leaf apex, those toward the base widely spaced and reduced to spines, median leaflets 23–48 cm (9.1–19 in) long, 8–10 mm (0.3–0.4 in) wide, linear lanceolate, straight, gradually tapered to a pungent apex, narrowed toward the cream or reddish anterior callus at the attachment, margin flat and entire. Female cones usually solitary but reported as sometimes two or three, rarely as many as seven, ovoid, 25–35 cm (10–14 in) long, 14–18 cm (5.5–7.1 in) in diameter. Peduncle 10–15 cm (4–6 in) long, 3–4 cm (1.2–1.6 in) in diameter. Sporophyll face 23–35 mm (0.9–1.4 in) high, 60–70 mm (2.4–2.8 in) wide, glaucous, apical spine flattened, erect, 1–5 cm (0.4–2 in) long, longest at the cone apex. Sarcotesta bright red when ripe. Sclerotesta irregularly ovoid, often somewhat flattened, 4.5–5 cm (1.8–2 in) long, 2.5–3.5 cm (1–1.4 in) in diameter, the surface more or less smooth except for numerous shallow, indistinct, longitudinal grooves. Male cones usually two to five but six or seven not uncommon, cylindrical, 29–41 cm (11–16 in) long, 11–15 cm (4.3–6 in) in diameter. Peduncle 10–18 cm (4–7.1 in) long. Sporophylls 32–50 mm (1.3–2 in) long. Sporophyll face 25–33 mm (1–1.3 in) wide, glaucous, apical spine upturned, triangular to elongate, 8–75 mm (0.3–3 in) long, almost absent on lower sporophylls, longest on upper sporophylls. Sporangia in a single heart-shaped patch. HABITAT: Coastal dry and wet sclerophyll forest and woodland, or in low scrub, generally in sand, sandy loams, to laterites. Rainfall is 250–1000 mm (10–40 in) annually, falling mostly in winter. The climate is temperate, with hot, dry summers and cool to cold winters with frequent frosts. DISTRIBUTION: Australia, Western Australia, southwestern and southern coast regions from Dwellingup to Albany, west to the coast.

Macrozamia riedlei is one of the three species of the genus endemic to Western Australia, the others being *M. dyeri* and *M. fraseri.* It was first described as a *Cycas* by Charles Gaudichaud-Beaupré in 1829. Charles A. Gardner transferred it in 1930 to *Macrozamia* where it rightfully belongs. The type specimen of *M. riedlei* was collected in the vicinity of King George Sound, near Albany. *Macrozamia* in Western Australia ranges from about Gingin, north of Perth, south and east to Cape Arid, to the east of Esperance. Over this extensive range there is a great deal of variation in the cycads. For many years all these populations were accepted by most taxonomists as *M. riedlei.* Two of these species were *M. dyeri,* which was taken out of synonymy under *M. riedlei* by David L. Jones in 1993, followed by *M. fraseri* in 1998 (Hill et al. 1998). Additional field investigations will be necessary to ascertain if other forms worthy of taxonomic recognition are to be found in Western Australia.

In cultivation, *Macrozamia riedlei* grows well in either full sun or light shade and develops into an attractive cycad. In my experience, it is not as easy to grow as *M. macdonnellii,* and occasionally a reasonably well established plant will die for no apparent reason. Usually such deaths have occurred only in plants collected from the wild. Plants grown from seed are not at all difficult in cultivation and have a fairly rapid growth rate. This is a large cycad when it is mature and should prove useful as a landscape plant in temperate areas that experience moderate frosts.

The conservation status of *Macrozamia riedlei* is quite secure. Like other species of the genus, *M. riedlei* has been implicated in stock poisoning and local ranchers have destroyed large numbers of this cycad. In spite of these losses, *M. riedlei* is still reasonably common over its extensive range, and large amounts of viable seed are produced annually. Seedling regeneration is good, and this species, at least at present, does not appear to be threatened.

Macrozamia secunda (Bentham) C. Moore 1884

PAGE 248, PLATES 408, 409

Macrozamia spiralis var. *secunda* Bentham 1873, *M. tridentata* var. *secunda* (Bentham) J. Schuster 1932

The epithet for *Macrozamia secunda* is derived from *secundus,* Latin for next or following and meaning turned toward the same side, referring to the two rows of leaflets with their upper surfaces turned toward each other to produce a boat-shaped leaf. STEMS subterranean, about 20 cm (8 in) long, 8–15 cm (3.2–6 in) in diameter, with contractile roots that continue to pull the stem into the ground. LEAVES usually 2–12 in the crown, dull to semiglossy, gray-green or blue, at first erect, later spreading, 60–80 cm (24–32 in) long, 10–20 cm (4–8 in) wide, strongly keeled. Petiole 5–15 cm (2–5.9 in) long, 5–9 mm (0.2–0.4 in) in diameter, concave above the basal section, flat or rounded above in the medial and apical section, with two narrow, often indistinct lateral grooves decurrent from the base of the leaflets, rounded to angular below. Rachis not twisted or scarcely so but curved backward and downward near the apex. Leaflets in 40–85 pairs, suberect and with their upper surfaces turned toward each other, slightly twisted at the base and more or less forwardly directed, crowded, the lowest leaflets only 1–2 cm (0.4–0.8 in) apart, rather rigid, linear, straight or falcate, median leaflets 8–20 cm (3.2–8 in) long, 3–8 mm (to 0.3 in) wide, abruptly tapered toward the pungent or two- or three-toothed apex, tapered toward the cream or pinkish and slightly callous base, dull green or glaucous, especially on the lower surface, with stomata on the lower surface only, the upper surface convex in cross section, margin entire or sometimes with two or three small apical teeth. FEMALE CONES usually solitary, cylindrical or ovoid cylindrical, 15–25 cm (6–10 in) long, 7–9 cm (2.8–3.5 in) in diameter, inner parts of ripe cone bright salmon pink, the spinelike cataphylls hidden among the leaf bases, some shorter ones often present on the peduncle. Peduncle 15–20 cm (6–8 in) long, 2–3 cm (0.8–1.2 in) in diameter. Sporophylls 3–4 cm (1.2–1.6 in) long. Sporophyll face 1.5–3 cm (0.6–1.2 in) high, 3.5–6 cm (1.4–2.4 in) wide, glaucous, apical spine flattened, more or less erect, shortest 2–5 mm (to 0.2 in) long at the cone base, longest 10–33 mm (0.4–1.3 in) long at the apex, 3–7 mm (to 0.3 in) broad at its base. Sarcotesta scarlet when ripe. Sclerotesta 20–35 mm (0.8–1.4 in) long, 17–25 mm (0.7–1 in) in diameter. MALE CONES usually one to four, cylindrical or ellipsoid cylindrical, 15–20 cm (6–8 in) long, 4–5 cm (1.6–2 in) in diameter. Peduncle 20–40 mm (0.8–1.6 in) long, 10–13 mm (0.4–0.5 in) in diameter. Sporophylls cuneate or cuneate obovate, 1.5–2.5 cm (0.6–1 in) long. Sporophyll face 1.5–2 cm (0.6–0.8 in) wide, apical spine erect, flattened, to 10 mm (0.4 in) long, longest at the cone apex, 2–5 mm (to 0.2 in) broad at the base. Sporangia in a single patch covering the entire undersurface of the sporophyll. **Habitat:** Dry, open, sclerophyll forest in sandy or stony soils, often on slopes and ridges. Rainfall averages 500–1000 mm (20–40 in) annually, falling evenly throughout the year. The climate is temperate, with hot summers and cool to cold winters with frequent frosts. **Distribution:** Australia, New South Wales, central western slopes and lower elevations of the Central Tablelands, from near Gilgandra to Grenfell, east to the main divide from Mudgee to Capertee.

Macrozamia secunda is a small, rather pretty cycad that is not often seen in collections. It is not easily found in its habitat and, when located, occurs in small scattered colonies. This may explain, in part, the lack of plants in cultivation. This species, like most macrozamias, seems to be quite tolerant of frost. One problem in cultivation can be the sudden death of a specimen for no apparent reason. It would appear that these losses usually occur because the soil is not well drained and that root rot travels into the stem, causing the plant's death. Leaves are usually produced annually, cones rarely. Only three of the six plants in my garden have produced cones even though they are mature and have been in cultivation for 15 years. No doubt this species, as others of section *Parazamia,* exhibits a strong cyclical coning pattern. This coning pattern is probably linked to weather conditions, perhaps a combination of temperature and rainfall.

Sufficient data are not available to assess the conservation status of *Macrozamia secunda* properly. From the information that is available it would appear that *M. secunda* is not common in its habitat and that the total number of plants is quite small. For these reasons the species must be considered threatened and should be afforded protection wherever possible.

Macrozamia spiralis (Salisbury) Miquel 1842

PLATE 410

Zamia spiralis Salisbury 1796, *Encephalartos spiralis* (Salisbury) Lehmann 1834

Macrozamia corallipes J. D. Hooker 1872

The epithet for *Macrozamia spiralis* is Latin for spiral, referring to the usual twisting of the rachis in this cycad, giving a somewhat spiral appearance to the leaves. **Stems** mostly subterranean, rarely branched, to 30 cm (12 in) long, 8–20 cm (3.2–8 in) in diameter. **Leaves** usually 2–12, rarely as many as 17, at first erect, later spreading, 0.6–1 m (2–3.3 ft) long, 20–30 cm (8–12 in) wide, moderately keeled. Petiole 15–40 cm (6–16 in) long, 4–8 mm (to 0.3 in) in diameter. Rachis straight to spirally twisted through as much as one revolution, more or less round in cross section. Leaflets in 22–60 pairs, flat, spreading but the two ranks not in the same plane, curved backward and downward, forwardly directed, twisted at the base so as to be forward facing, falcate, linear, entire or sometimes two- or three-toothed at the apex in immature plants, median leaflets 12–20 cm (4.7–8 in) long, 5–10 mm (0.2–0.4 in) broad, gradually tapered to a mucronate apex, narrowed at the base to a pinkish, reddish, or yellowish, slightly callous attachment, dull dark green or slightly glaucous, with stomata only on the lower surface, margin flat and entire. **Female cones** solitary, rarely two, ovoid, 12–20 cm (4.7–8 in) long, 7–9 cm (2.8–3.5 in) in diameter. Peduncle 15–20 cm (6–8 in) long, 2–3 cm (0.8–1.2 in) in diameter. Sporophyll face 1.5–2.5 cm (0.6–1 in) high, 3.5–5.5 cm (1.4–2.2 in) wide, glaucous, apical spine flat, upright, shortest 2–5 mm (to 0.2 in) long at the cone base, longest 13–30 mm (0.5–1.2 in) long at the apex, 3–8 mm (to 0.3 in) wide at its base. Sarcotesta orange to scarlet when ripe. Sclerotesta 25–30 mm (1–1.2 in) long, 19–25 mm (0.8–1 in) in diameter, the surface with numerous indistinct, shallow, longitudinal grooves. **Male cones** usually one to four, cylindrical or ellipsoid cylindrical, 15–20 cm (6–8 in) long, 5–6 cm (2–2.4 in) in diameter. Peduncle 8–15 cm (3.2–6 in) long, 2–3 cm (0.8–1.2 in) in diameter. Sporophyll face 15–22 mm (0.6–0.9 in) wide, apical spine erect, spreading, flattened, to 15 mm (0.6 in) long, longest at the cone apex. Sporangia in a single patch. **Habitat:** Understory of dry to semiwet open sclerophyll forest, usually in flat areas, on poor, sandy or gravelly soils. Rainfall averages about 800 mm (32 in) annually, falling throughout the year. The climate is temperate, with hot summers and cold winters with frequent frosts. **Distribution:** Australia, central eastern New South Wales, from Dunedoo and the valley of the Goulburn River to the Blue Mountains in Sydney and Waterfall districts.

Macrozamia spiralis is a small and rather pretty cycad with dark green leaves, usually exhibiting a pinkish or reddish callous attachment at the base of each leaflet. This cycad is rather rare in collections, and if plants labeled *M. spiralis* are found they usually turn out to be *M.*

communis, with which this species was confused for many years. The two species are easily distinguished as *M. spiralis* has short, moderately keeled, twisted leaves and a reddish callus at the base of its narrow leaflets whereas *M. communis* has long, flat, arching leaves and a white or cream callus at the base of its broad, dark green leaflets.

In cultivation the growth of *Macrozamia spiralis* is much more rapid than in habitat, but the overall rate is slow and sizable specimens cannot be produced in a few years. Cultivated plants tend to hold many more leaves than a similarly sized plant in the wild. This species is cold tolerant to several degrees below freezing. Potting poses no major problems for this cycad, and it may be used as a container plant for the house or outdoors. When grown in the ground, it is a useful plant for small garden areas.

Macrozamia spiralis is found in scattered colonies within its range, but never in great numbers. Seed production is normally good but tends to be cyclic, as in other species of the genus. Seedling regeneration in habitat is good, and this species is not considered as threatened.

Macrozamia stenomera L. A. S. Johnson 1959

PLATE 411

Macrozamia heteromera var. *tenuifolia* C. Moore 1884
Macrozamia heteromera var. *dicranophylloides* J. Schuster 1932
Macrozamia heteromera var. *tenuifolia* J. Schuster 1932, illegitimate name, not C. Moore 1884

The epithet for *Macrozamia stenomera* is derived from *stenos,* Greek for narrow, and *meris,* part, referring to the very narrow leaflet divisions. **Stems** mostly subterranean, rarely branched, 20–37.5 cm (8–15 in) long, 10–20 cm (4–8 in) in diameter. **Leaves** usually 2–10, at first erect, later spreading, 40–80 cm (16–32 in) long, 20–40 cm (8–16 in) wide. Petiole 7–15 cm (2.8–5.9 in) long, 5–9 mm (0.2–0.4 in) in diameter. Rachis more or less twisted, usually through one-quarter to one revolution, curved backward and downward, flat or somewhat concave, with two narrow shallow grooves decurrent from the base of the leaflets. Leaflets in 35–60 pairs, spreading but the two ranks not in the same plane, forwardly directed, twisted so as to face toward the apex of the leaf, somewhat open and loose, crowded above but spaced 1.3–4 cm (0.5–1.6 in) apart toward the base, one to four times dichotomously divided, forming a fanlike arrangement, lowest leaflets not much reduced and never spinelike, median leaflets 10–20 cm (4–8 in) long with the divisions 2–4 mm broad, abruptly rounded to the mucronate or two-toothed apex, narrowed toward the yellowish, reddish, or orange callous base, dull green above, lighter below, with stomata only on the lower surface. **Female cones** solitary, rarely two, cylindrical ovoid, 20–24 cm (8–9.4 in) long, 7–9 cm (2.8–3.5 in) in diameter, glaucous. Peduncle erect, 4.5–6 cm (1.8–2.4 in) long, 2.5 cm (1 in) in diameter. Sporophyll face 2.5–3 cm (1–1.2 in) high, about 5 cm (2 in) wide, excluding the spine, apical spine erect or spreading, to about 1.5 cm (0.6 in), longest at the cone apex. Sarcotesta yellow when ripe, green where exposed to sunlight between the sporophylls. Sclerotesta irregularly globular to short ovoid, 24–27 mm (1–1.1 in) long, 20–25 mm (0.8–1 in) in diameter, the surface more or less smooth with numerous shallow, irregular, indistinct longitudinal grooves. **Male cones** usually solitary but may be two or more, erect, cylindrical, 13–19 cm (5.1–7.5 in) long, 5–6 cm (2–2.4 in) in diameter, light yellow-green when mature. Peduncle erect, 6–8 cm (2.4–3.2 in) long, 1.5–2 cm (0.6–0.8 in) in diameter. Sporophyll face 8 mm (0.3 in) high, 15–20 mm (0.6–0.8 in) wide, exclusive of the spine, apical spine erect, flattened, 2–15 mm (to 0.6 in) long, longest toward the cone apex. Sporangia in two patches near the cone apex but in a single patch on lower sporophylls. **Habitat:** Dry sclerophyll forest on stony but not siliceous hillsides at elevations of 1000–1500 m (3300–4900 ft). Rainfall averages 1100 mm (43 in) annually, falling mainly in spring and summer. Temperatures range from summer highs of 35°C (95°F) to winter lows of −11°C (12°F). Frosts occur frequently, about 30 days per year, and snow about four or five times per year. **Distribution:** Australia, northern and northwestern New South Wales, and the western extension of the Northern Tablelands in the Nandewar Range.

Lawrence A. S. Johnson described *Macrozamia stenomera* in 1959. Its existence had been known for many years prior to that but it had been considered a variety of *M. heteromera.* In 1884 Charles Moore named it *M. heteromera* var. *tenuifolia.* Then in 1932 Julius Schuster described *M. heteromera* var. *tenuifolia* as new, ignoring Moore's earlier name, and also published *M. heteromera* var. *dicranophylloides,* based on the same material. There is no question that *M. stenomera* is clearly related to *M. heteromera,* but it is distinct both ecologically and morphologically. The leaflets of *M. stenomera* are more divided, the divisions are narrower, stomata are lacking on the upper surface, and the rachis is generally twisted. If ripe female cones are present the two species can be easily separated as the sarcotesta of *M. stenomera* is yellow, that of *M. heteromera* red.

Macrozamia stenomera is one of the most interesting macrozamias. The leaves are very feathery because of the multiple divisions of each leaflet. The branching of the leaflets gives each leaflet a fan-shaped outline. These characteristics coupled with the twisted rachis give each leaf the appearance of a feather or plume that is quite striking. In habitat, the effect is more fernlike, and the plants are quite difficult to locate among the grass and other vegetation with which they grow.

As with other macrozamias, the annual fires do not appear to affect the health of these mainly subterranean stemmed plants. The only fire damage sustained by them is defoliation and the destruction of cones and seeds. The seeds are also fed upon by various small animals, thereby reducing the numbers for seedling regeneration.

In the Tamworth area of New South Wales, about 140 km (87 miles) southeast of the town of Narrabri, where *Macrozamia stenomera* is situated, there occurs a distinctive cycad that is clearly related to it. This plant differs from the Narrabri populations of *M. stenomera* in its blue leaves and distinctive reddish callus (Plate 412). This reddish color is also prominent on the leaflet, from its attachment to the rachis up to and including the first leaflet division. The plants in this population also differ from typical *M. stenomera* in that their leaflets have not been observed to divide more than twice. There is a possibility that additional investigation of this population may reveal differences sufficient for taxonomic recognition.

Macrozamia stenomera is not common in cultivation because of its relative scarcity in the wild and its very sporadic seed production. Often, several years will pass before a coning cycle occurs with a resultant seed crop. During the rare periods of seed production, numerous female cones appear and hundreds of seeds may be harvested. The seed germinates easily but the growth of the seedling is relatively slow. Usually no more than two or three leaves are produced in the seedling's first year of growth, even with the advantage of sufficient water and fertilizer. The seedlings can be identified easily as even the first leaf displays the distinctive branching of the leaflets. Plants in habitat appear to grow very slowly, and large specimens must be extremely old. *Macrozamia stenomera,* because of the high elevation of its habitat and the frequent frosts and snow occurring there, can be considered one of the most cold hardy of the macrozamias.

Although a considerable portion of the population of *Macrozamia stenomera* is found within the confines of Mount Kaputar National Park, numerous plants have been removed in relatively recent times. Because of its slow growth and limited numbers, *M. stenomera* must be considered endangered and afforded whatever protection is possible for its continued survival.

Macrozamia viridis D. L. Jones & P. I. Forster in Forster & Jones 1994

PLATE 413

The epithet for *Macrozamia viridis* is Latin for green, referring to the distinctive bright green leaves. **Stems** subterranean, more or less ovoid, 10–20 cm (4–8 in) in diameter, often dividing into five or six crowns. **Leaves** usually one to five, 35–60 cm (14–24 in) long, erect or spreading, spirally twisted one to three times, bright to deep glossy green. Petiole 9–21 cm (3.5–8.3 in) long, 8–14 mm (0.3–0.6 in) in diameter at the lowest leaflet, flat to slightly convex above, strongly convex below. Leaflets in 40–80 pairs, in more or less two ranks but not always in opposite pairs, 2–20 mm (to 0.8 in) apart, the longest leaflets at the middle of the leaf, becoming shorter both above and below, apex acute to acuminate, the callous base yellowish white to reddish orange, median leaflets broadly linear, crowded, angled forward about 60°, obliquely erect to spreading, 7–20 cm (2.8–8 in) long, 3–11 mm (to 0.4 in) wide, glossy dark green above, green below, somewhat thick textured, not twisted except at base, the upper surface concave in cross section, margin flat and entire. **Female cones** solitary, erect, ovoid, 8–14 cm (3.2–5.5 in) long, 5.5–7 cm (2.2–2.8 in) in diameter. Peduncle furrowed, 12–16 cm (4.7–6.3 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, elliptical in cross section. Sporophylls 2–2.5 cm (0.8–1 in) long. Sporophyll face 1–1.5 cm (0.4–0.6 in) high, 3–5 cm (1.2–2 in) wide, with a prominent small depression just below the apical spine, apical spine to 15 mm (to 0.6 in) long, longest at the cone apex. Sarcotesta orange to red when ripe. Sclerotesta broadly oblong ovoid, 20–28 mm (0.8–1.1 in) long, 20–24 mm (0.8–0.9 in) in diameter, the surface smooth except for 12–15 shallow longitudinal grooves. **Male cones** solitary, erect, more or less cylindrical, 9–18 cm (3.5–7.1 in) long, 3.5–5 cm (1.4–2 in) in diameter. Peduncle 8–15 cm (3.2–6 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, round in cross section, shallowly furrowed. Sporophylls 1.5–2 cm (0.6–0.8 in) long. Sporophyll face 12–18 mm (0.5–0.7 in) wide, apical spine in the lower third to half of the cone vestigial, becoming longer toward the apex, to 15 mm (0.6 in), with a prominent, small sunken depression below the spine. Sporangia in a single heart-shaped patch except for those in the apical portion of the cone that are sometimes divided into two separate patches. **Habitat:** Open, wet *Eucalyptus* woodland dominated by large granite outcrops in deep granitic soils. DISTRIBUTION: Australia, southeastern Queensland, Darling Downs district, vicinity of Girraween and Wyberba.

The description of *Macrozamia viridis* is based on specimens collected in 1993 by David L. Jones, Paul I. Forster, and Peter Machin. *Macrozamia viridis* is most similar to *M. fawcettii* with its twisted leaves and broad leaflets. It can be distinguished from that species by the overall smaller size of its parts and its distinctively flattened petiole.

Like other species of section *Parazamia, Macrozamia viridis* is a dwarf plant with a subterranean stem and few, short, somewhat twisted leaves. This cycad, with its compact crown of glossy bright green leaves, is one of the handsomest of the section. *Macrozamia viridis* would no doubt become an exceptional pot plant, but its slow rate of growth from seed makes it a poor candidate for commercial growers, probably confining its culture to collectors.

As with other species of section *Parazamia,* the distribution of *Macrozamia viridis* is very restricted. Only two populations are known in Queensland, one in Girraween National Park, the other near Wyberba. Because of its slow rate of growth from seed, illegal collection of wild plants for commercial purposes cannot be dismissed, and overcollection could soon pose a threat to the continued survival of this species in its habitat. It is hoped that sufficient protection can be provided to assure the continued existence of *M. viridis* within its restricted range.

Microcycas (Miquel) A. de Candolle 1868

Zamia sect. *Microcycas* Miquel 1852

The name *Microcycas* is derived from *micro-,* Greek for small, and *Cycas.* One species (type, *M. calocoma*). Chromosome number $2n = 26$. *Microcycas* together with most of the other cycad genera constitute the family Zamiaceae.

Microcycas calocoma (Miquel) A. de Candolle 1868

PLATES 4, 7, 414–417

Zamia calocoma Miquel 1852

Microcycas calocoma, the epithet derived from *calos,* Greek for beautiful, and *come,* hair, meaning beautiful crown of leaves, is called *palma corcho,* cork palm, in Spanish, referring to the soft, corklike bark of older specimens. **Stems** normally solitary, not suckering from the base but often branched as a result of injury, to 10 m (33 ft) tall and 60 cm (24 in) in diameter, the bark smooth or ridged, younger portions of the stem exhibiting conspicuous leaf scars, leaf bases and cataphylls not persistent and soon shed, leaving the stem with a smooth, skinlike outer surface. Cataphylls 4–6 cm (1.6–2.4 in) long, 1.5–2 cm (0.6–0.8 in) wide, often twisted at the tip, densely tomentose with long gray hairs. The stems are not very woody, and injury is usually caused by hurricanes snapping off the apex when a full crown of leaves is present. With age the smooth skin is replaced with a corklike bark that insulates and to some degree protects the plant from fires. The maximum stem height of about 10 m (33 ft) places *Microcycas* among the larger cycads. **Leaves** 6–40 in mature plants, sporadically produced and not uncommon to find some plants dormant and leafless, bright dark green, more or less stiff, 60–100 cm (24–40 in) long, 16–24

Microcycas calocoma

cm (6.3–9.4 in) wide, emergent leaves lightly tomentose but soon glabrous. Petiole unarmed, terete, swollen at the base, about 10 cm (4 in) long. Leaflets in 50–80 pairs, opposite to alternate, 8–18 cm (3–7.1 in) long, not much reduced in length at apex or base, giving the leaf apex a cut-off appearance, 1–1.5 cm (0.4–0.6 in) wide, falcate, deflexed, veins more prominent above than below, apex bluntly pointed, margin entire and slightly revolute, flexible. It is not known whether the dormancy is the result of periods of drought or is a normal resting stage possibly brought on after cone production. Leaf size is small in comparison to other cycads with stems of similar size. One of the most distinctive features of the leaves of *Microcycas* is the apex. The leaflets are only slightly reduced in length toward the leaf apex, giving the appearance that the tip of the leaf has been cut off. Leaflets are narrow, linear, and deflexed from the rachis, providing a graceful appearance to the leaf. Female cones solitary, at first erect, then pendent below the leaf crown, long cylindrical, 50–94 cm (20–37 in) long, 13–16 cm (5.1–6.3 in) in diameter, tapering slightly from base to blunt apex, densely gray tomentose, Peduncle short, densely gray tomentose, covered by densely tomentose scales 6–10 cm (2.4–4 in) long that extend to the base of the cone. Median sporophylls 4.5–5.5 cm (1.8–2.2 in) long. Sporophyll face blunt, subquadrangular and sometimes furrowed, 2–3 cm (0.8–1.2 in) high, 3–4 cm (1.2–1.6 in) wide, with clearly defined facets, entire outer portion of the sporophyll face covered by a dense mass of closely pressed grayish hairs, with two seeds to each sporophyll, the seeds small and ready to germinate at shedding, in some cases beginning to germinate while still in the cone. Sarcotesta pink to red, 3.5 cm (1.4 in) long, 13–18 mm (0.5–0.7 in) in diameter. Sclerotesta elongate cylindrical, 2.5–3 cm (1–1.2 in) long, 1.2 cm (0.5 in) in diameter, light brown, smooth. Male cones usually solitary, sometimes two cones in sequence, erect, cylindrical, 25–30 cm (10–12 in) long, 5–8 cm (2–3 in) in diameter, slightly narrowing from the base toward the blunt apex. Peduncle about 2.5 cm (1 in) long, densely gray tomentose. Median sporophylls 2–2.5 cm (0.8–1 in) long, 1.5–2 cm (0.6–0.8 in) wide, the lower surface densely covered by sporangia, the apical third gray tomentose, prominently ridged along the median line, obtusely pointed. Habitat: Low, grassy to bushy hillsides and ravines, among trees or under them, often close to streambeds, in relatively dry areas with acid clay soil and outcrops of limestone, at elevations of 30–90 m (100–300 ft), very few occurring on flat grassland and not seeming to prefer any particular exposure. Distribution: Cuba, sierras of the western part of the island in Pinar del Río province, the mountains northwest of San Diego de los Banos, through the Santa Catalina region, to the mountain Cuchillo de Pinar near San Andrace.

Of the genera of cycads, only two, *Microcycas* and the South African *Stangeria,* are represented by only a single species each. *Microcycas* is a relict with a very restricted range. First described as a *Zamia* in 1852 by Friedrich Anton Wilhelm Miquel, it was recognized as a distinct genus in 1868 by Alphonse de Candolle. It was originally collected by Charles Wright in Cuba. During the early days of botanical exploration, not much was known about *Microcycas.* This was true for many plant taxa in an era when collectors would sometimes send back herbarium specimens of immature plants with brief, sometimes misleading collection data. This may explain why this cycad, which attains a stem height of 10 m (33 ft), was given the name *Microcycas,* small *Cycas.* In truth, *Microcycas* at maturity is larger than three-quarters of the known species of *Cycas*!

Its closest relative is *Zamia,* to which it is similar in several characteristics. But it takes only a glance to recognize that *Microcycas* is a distinctive cycad. The leaves are straight and generally held at right angles to the stem. The leaflets are falcate, drooping from the rachis, and do not shorten appreciably toward the leaf apex, thus giving the leaf a chopped-off look. This most distinctive characteristic is prominent in adults and seedlings alike, making them easy to identify.

Microcycas has a very limited area of distribution with relatively few individual plants remaining in the wild. Its habitat has been reduced through clearance of land for lumbering and farming. Some locals use the plants as *candelas,* lighting the crown of dried leaves to produce a giant candle, damaging or sometimes killing the stem apex.

Microcycas must be considered one of the most endangered cycads. Seedling regeneration (Plate 4) is all but nonexistent in the wild. Studies of the natural populations disclosed the fact that the female cones are not being fertilized and therefore are not producing viable seed. There are several theories as to why this has happened. One is that insect pollinators may have been eradicated by the use of pesticides on nearby crops. Another, based on wind pollination, is that possibly the climate has become drier and cooler, therefore the female cones, in an effort to save energy, are not becoming receptive. Since both female and male cones of *Microcycas* produce a strongly disagreeable odor when they are receptive, a biological pollinator is almost certainly involved. Cuban researchers report that male cones in naturally occurring plants produce an abundance of pollen. Observation of the female cones, however, disclose that they are not opening to allow the entrance of pollen, whether borne by insect or wind. This may well be the females' response to stress caused by reduced rainfall. A very few female plants were found that produce some viable seed each year, as noted because only the sporophylls bearing fertilized ovules enlarge. The reportedly receptive female cones of *Microcycas* generally produce a vertical crack or cracks between the sporophylls. In species of *Zamia,* this receptive type is usually associated with insect pollinators. Still another theory is that reduced seed production could be the result of a decrease in the availability of water or light. Sunlight can sometimes be critical in cone formation and development. Plants shaded by trees and brush that have grown up around them may be affected adversely.

It has been reported that under habitat conditions, both female and male cones take 4 months from inception, usually in May or June, to mature in September. An additional 10 months is needed for the cone to ripen, usually in July of the following year, or 14 months in all. At the time of seed shedding, the female cone is pendent below the leaf crown. *Microcycas* seed has a short viability and will not survive much beyond 4 months after being shed. When planted properly, the seed will germinate in 15–20 days. A strong taproot is produced, as is the case in many of the cycads adapted to dry conditions, with the first leaf emerging in about 8 months. The seedlings are quite slow growing in the wild but undergo rapid growth in cultivation. Instances are recorded of a seedling bearing its first cone in 8 years. In subtropical climates such as southern Florida and Hawaii, *Microcycas* may produce 10–20 cm (4–8 in) of stem per season with proper water and fertilization.

Microcycas does not do well in cold and will defoliate in frost conditions. Subfreezing temperatures will either cause defoliation or stem damage, or kill unprotected plants. *Microcycas* does not seem to have a problem with year-round watering, but if possible it should be kept drier during the winter months. That would correspond to conditions in its natural habitat, which has summer rainfall.

Not much has been done in the way of artificial propagation of *Microcycas.* This is basically the result of a lack of parental stock in cultivation. The Fairchild Tropical Garden, Miami, Florida, was fortunate to obtain both sexes of *Microcycas.* The seeds produced from these plants have been responsible for almost doubling the world's population of this rare cycad. This type of conservation strategy may one day make *Microcycas* available in large numbers. Because of its limited range and decreasing numbers in the wild, now thought to be fewer than 600, *Microcycas* must be considered extremely endangered. Every effort should be taken to protect it in the wild and to propagate it in cultivation. *Microcycas calocoma* is listed in Appendix I of CITES.

Stangeria T. Moore 1853

Stangeria is named in honor of William Stanger, surveyor general of Natal, South Africa. One species (type, *S. paradoxa* = *S. eriopus*). Chromosome number 2*n* = 16. *Stangeria* together with *Bowenia* constitute the family Stangeriaceae.

Stangeria eriopus (Kunze) Baillon 1894

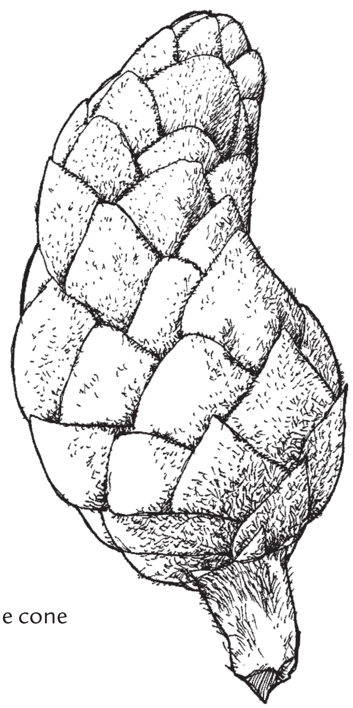
PAGES 2–3, PLATES 418–423

Lomaria eriopus Kunze 1839
Lomaria coriacea in the sense of Kunze 1836, not *L. coriacea* Schrader, a fern
Stangeria paradoxa T. Moore 1853
Stangeria schizodon W. Bull 1872, *S. paradoxa* f. *schizodon* (W. Bull) J. Schuster 1932, *S. paradoxa* var. *schizodon* (W. Bull) Marloth 1913
Stangeria katzeri Regel 1874, *S. paradoxa* var. *katzeri* (Regel) Marloth 1913
Stangeria sanderiana hort. ex J. Schuster 1932, as a synonym, illegitimate name

Stangeria eriopus, the epithet derived from *erio-*, Greek for woolly, and *-pus,* foot, no doubt referring to the tomentum covering newly emergent leaves rather than the velvety surface of the cones (unknown when this cycad was first named), is called *bobbejaankes,* baboon food, in Afrikaans, *imfingo* in Zulu, *umfingwani* in Xhosa for the whole plant or *umncuma* for the cone only, and *finguane* and *juma* in southern KwaZulu-Natal province. **Stems** subterranean, tubers often branching in old age to form multiheaded plants, more or less carrot shaped in single-headed specimens, 10–25 cm (4–10 in) in diameter, apex producing woolly cataphylls that are soon shed, leaving a smooth, light brown epidermis. **Leaves** usually one to

Stangeria eriopus

three at each growing point or crown, produced singly but ultimately producing two to three or more each season, emergent leaves circinate, usually green but sometimes copper colored, covered with a velvety white tomentum, mature leaves fernlike, pinnate, 0.3–2 m (1–6.6 ft) long, about half this length the petiole, shortest in plants from grassland habitats, longest in plants from forest habitats. Leaflets in 5–20 pairs, opposite to subopposite, unarmed except for minor serrations along the margins of some leaflets, slightly leathery and varying considerably in texture, size, and margin, each with a distinct midrib and dichotomously branching lateral veins, lower leaflets stalked but upper leaflets decurrent and fused at their bases, with obscure lateral veins branching out from the midrib, giving a featherlike outline. **Female cones** solitary, ellipsoid to ovoid, to 18 cm (7 in) long and 8 cm (3.2 in) in diameter, with a velvety white to tan tomentum when immature, becoming glabrous with age, apex blunt, rounded. Peduncle 28–40 mm (1.1–1.6 in) long, 22–30 mm (0.9–1.2 in) in diameter, tomentose. Sporophylls to 6 cm (2.4 in) long, spirally arranged to produce as many as six vertical columns, each sporophyll with two ovules. Sporophyll face about 4 cm (1.6 in) high and 6 cm (2.4 in) wide, the outer surface slightly convex and smoothly overlapping the sporophyll above. Sarcotesta dark red, to 3.5 cm (1.4 in) long and 2.5 cm (1 in) in diameter. Sclerotesta more or less ovoid, about 2.5 cm (1 in) long, 1.4–2 cm (0.6–0.8 in) in diameter, light brown, with an extended round appendage with 10–12 ridges, starting at the chalaza and disappearing halfway to the opposite end. Chalaza round, 8–10 mm (0.3–0.4 in) in diameter, protruding 2–3 mm, with 5–10 pits in its surface. **Male cones** solitary, erect, subcylindrical, 10–25 cm (4–10 in) long, 3–4 cm (1.2–1.6 in) in diameter, tapering toward the apex, covered with a silvery white velvety tomentum when immature, glabrous at maturity and yellow-brown. Peduncle about 6 cm (2.4 in) long and 1 cm (0.4 in) in diameter, tomentose. Sporophylls triangular or rhomboid when seen from above, 12 mm (0.5 in) long. Sporophyll face 4–6 mm (0.2 in) high, about 12 mm (0.5 in) wide. Sporangia separated into two distinct groups and covering the entire lower portion of the sporophyll. **Habitat:** Open, dry grassland, coastal parkland, or dense, damp lowland forest, from close to sea level to about 750 m (2500 ft), usually in sandy soil but sometimes in granitic or heavy black clays, all of which are slightly acid. Rainfall averages 750–1000 mm (30–39 in) annually, two-thirds of which falls in summer. Summer temperatures are high. Frost rarely occurs. **Distribution:** South Africa, KwaZulu-Natal and Eastern Cape provinces, a narrow strip usually no closer to the coast than 1–3 km (0.6–1.9 miles) nor farther inland than about 80 km (50 miles), from just south of the border with Mozambique to the vicinity of East London, Eastern Cape, in the south.



Stangeria female cone

Like the Cuban *Microcycas, Stangeria* is remarkable in being represented by only one species, one restricted to a relatively small area on the eastern coast of South Africa. It is remarkable also for its fernlike appearance, which caused it to first be described as a fern (*Lomaria*), not a cycad. It is not surprising that this interesting cycad has aroused considerable interest among botanists and collectors alike.

There are two distinct forms of *Stangeria,* the grassland form (Plates 418, 419) and the forest form (Plates 420, 421). The grassland form produces leaves barely 60 cm (24 in) long whereas the plants from dense forest may have leaves longer than 2.4 m (7.9 ft). Not only does the size of the leaf vary, the shape of the leaflets and their margins differ considerably as well. The number of leaves varies, grassland plants usually producing one leaf a season whereas forest plants may produce three or four. The forms seem to differ in their response to varying amounts of light and water. Drier conditions are encountered in open grassland, more humid conditions in the forest habitat.

Grassland plants normally hold only one leaf per crown as opposed to as many as 8–10 on forest plants. This is no doubt because the grasslands are burned each year, destroying the previous year's growth, whereas the forest seldom burns. The grassland form is known to produce multiheaded clumps to 2 m (6.6 ft) across whereas forest plants usually have but a single crown. Because the two forms maintain their differences when grown side by side and under the same conditions, I believe that two species may be involved. At Cycad 99, the Fifth International Conference on Cycad Biology, P. M. Resslar (2002) presented a paper on the two forms of *Stangeria* in regard to tissue culturing their petioles. He found that the petioles of the forest form produced callus very quickly whereas those of the grassland form could not be made to form callous growth. This is yet another indication that the two forms may be specifically distinct.

In cultivation, *Stangeria* grows easily and considerably faster than it does in the wild. Plants grown at the Arboretum of Los Angeles County, Arcadia, California, grew from seed to coning size in 5 years. At that stage the plants had 10–15 leaves and a tuber diameter of 10–12.5 cm (4–5 in).

Stangeria does best in a sandy open soil with considerable humus and at slightly acid pH. The soil should be kept moist but not wet. Fertilizer is well received and should be applied every 3–4 weeks during the growing season. In areas with cool winters, it is best to withhold feeding until spring. *Stangeria* can be grown in full sun but occasional hot days coupled with low humidity may cause leaf burn. A garden area with morning sun and afternoon shade seems to produce the best growth. Grown in a shady situation, *Stangeria* tends to produce more luxuriant growth. When planted in the garden, the tuber should always be below the soil line. This is the way the plants grow in their habitat, and in cultivation it protects them from extreme heat, cold, and mechanical damage from humans or other animals. Since the tuber is always underground, the only apparent differences between young and old plants are the size and number of leaves.

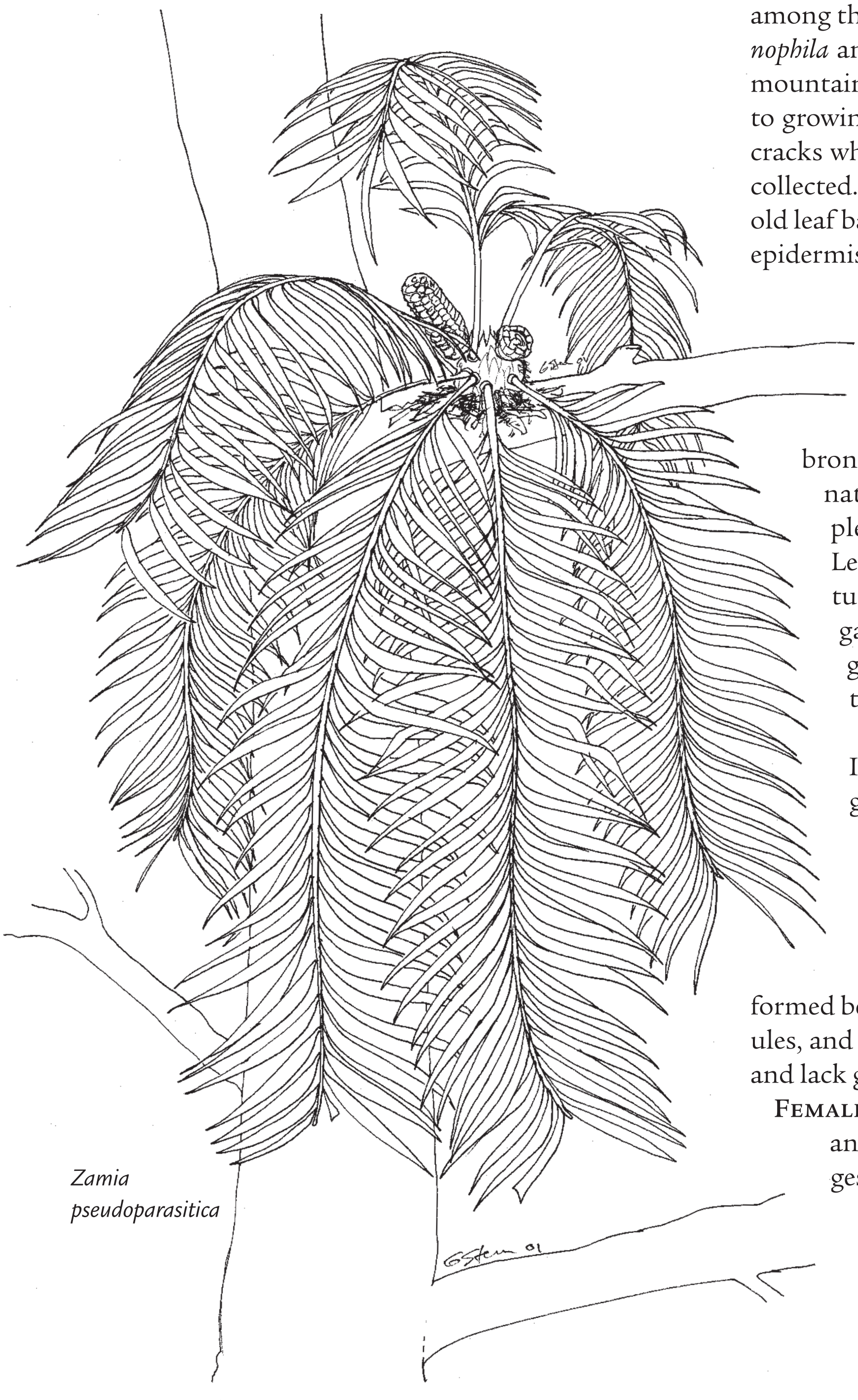
The cones of *Stangeria* are easily fertilized if pollen is available. The female cone shows when it is receptive by slightly opening the upper edge of the cone sporophylls, thus allowing pollen to be introduced. Maturation of the seed varies depending on temperature but usually takes 6–10 months. When the seed is developing, it eventually causes the cone sporophylls to spread, making the seed visible. The seed coat turns bright pink or red just prior to seed shedding. Shortly after the seed is shed, the fleshy seed coat or sarcotesta softens. At this time it should be removed, as it seems to inhibit germination, and the seed stored in a box or bag about 3 months while the embryo develops. The seed can then be planted and treated as explained in Chapter 5.

Until more recent times, *Stangeria* was locally common in its area of distribution. Because most of its habitat is in coastal regions, many plants have been destroyed through urbanization and land clearance for the cultivation of pineapples, sugarcane, and bananas. It has also been reported that many *Stangeria* plants have been removed from the wild for sale to collectors. The harvesting of *Stangeria* to meet the ever increasing demand by the users of traditional medicines must now be counted among the threats to this cycad. This industry has grown to the point where it was reported (Osborne et al. 1994) that an estimated 3410 tubers totaling 2380 kg (5250 pounds) were traded at Durban's Victoria and Isipingo medicinal plant markets during July 1992 alone. The popularity of *Stangeria* is rated in the top 15% of the 400-odd medicinal plant species traded at these markets. The remaining colonies show prolific regeneration and should be safe if they can be protected from poaching and land clearance. Reasonable protection should be provided in every possible way to ensure the safety of this unique cycad. *Stangeria eriopus* is listed in Appendix I of CITES.

Zamia Linnaeus 1763

Aulacophyllum Regel 1876a
Palma-filix Adanson 1763

The name *Zamia* is derived from Latin, meaning loss or damage, and originally used by Pliny the Elder (A.D. 23–79) in his *Historia Naturalis* to describe barren pinecones, a term transferred to cycads because of the similarity of their cones to pinecones. Sixty species (type, *Z. pumila*) with others in the process of being described. Chromosome numbers $2n$ = 16–18, 21–28. *Zamia* together with most of the other cycad genera constitute the family Zamiaceae.



Zamia pseudoparasitica

Stems generally subterranean tubers without much development of woody tissue, though several species producing aerial stems to a height of 4 m (13 ft) or more. Three species are quite divergent from the norm and have specialized to such an extent that they now grow under almost soilless conditions. One, *Zamia pseudoparasitica,* is an epiphyte growing on tree limbs with its roots anchored among the epiphytic vegetation. The other two, *Z. cremnophila* and an undescribed species of *Zamia* from the mountains south of La Ceiba, Honduras, have adapted to growing on limestone cliffs, their roots wedged into cracks where small pockets of leaf debris and soil have collected. Zamias that form aerial stems soon shed their old leaf bases and cataphylls to reveal a smooth skinlike epidermis, except for species of wet tropical habitats in which the stems are soon covered by epiphytic ferns, mosses, bromeliads, and so on.

Leaves long or short, erect, spreading or pendent, displaying even more variation than the stems, emergent leaves green, bronze, reddish, or purplish, sometimes a combination of these colors. Petiole and rachis completely unarmed or covered with fierce spines. Leaflets stiff and leathery, or soft and papery, texture smooth, prominently furrowed and corrugated, or somewhere in between, the surface glossy or dull, smooth or rough, margin entire, toothed, or serrate from base to apex.

Leaves are generally various shades of green. In some species with reddish or purplish emergent leaves, the color often persists on the rachis or leaflets for a considerable period of time. One species, *Zamia variegata,* is naturally variegated and has dark green leaflets that are spotted and streaked with cream or yellow. The cataphylls are produced in two forms: those formed before the leaves are short, broad, and have stipules, and those formed before the cones are long, thin, and lack glandlike stipules.

Female cones produced in a variety of sizes, shapes, and colors and coatings of tomentum. The largest, such as those of *Zamia lindenii* and *Z. roezlii,* are pendent below the leaf crown when mature and measure about 46 cm (18 in) long and 11.5 cm (4.5 in) in diameter. The smallest, those of

Z. pygmaea, are about 7.5 cm (3 in) long and 5 cm (2 in) in diameter. Color of the sarcotesta ranges from yellow through orange, pink, and red. Generally, *Zamia* seed does not store well. Seeds of tropical species are often ready to germinate as soon as they are shed from the cone. The more temperate species that generally go through a lengthy cold, dry period in winter usually take some time after shedding for the embryo to develop fully. For this reason, seeds of temperate species tend to store better.

Female cones of *Zamia,* if properly fertilized, take about 6–14 months to mature, with the average about 9 months. As the cone matures, the seeds generally enlarge to such an extent that they force the sporophylls apart. During this developmental stage the sarcotesta slowly changes color, usually to orange or red. While the seed is still attached to the sporophyll, the color of the sarcotesta is dull and the flesh stays quite hard. Once the cone has broken up, the seed rapidly completes the ripening process, the color changes and intensifies, and the sarcotesta becomes quite soft and rubbery.

Species of *Zamia* that have been studied for their fertilization processes have all proved to be insect pollinated. This will no doubt prove to be true for the remainder. Some species are thought to have a specific pollinator that is not attracted to other zamias or other genera of cycads.

The bright color of the seed coat of most *Zamia* species would seem to indicate a biological dispersal agent. Birds probably play an important role in seed dispersal, but rodents may prove to be equally active in this respect.

Male cones not as variable as the female cones. They are relatively small and both their growth and death are quite rapid. In some tropical species, male cones are produced in fairly large numbers and they ripen in sequence, giving a longer duration of pollen shedding and enhancing the probability of the female cone's fertilization. Once the male cone elongates and starts to shed its pollen, it will generally only live about a week. In drier areas the cones will usually be in evidence for several weeks or months whereas cones in hot, humid areas soon rot, and no evidence is left as to the plant's sex.

Habitat: *Zamia* covers the broadest spectrum of habitats of any of the cycad genera, with plants found in rain forest, savanna, coastal stabilized sand dunes, tidal swamps, and desert, from sea level to more than 2500 m (8000 ft). The genus includes *Z. pseudoparasitica,* an epiphyte, living only on branches high in trees. Other species have adapted to life on steep cliffs and have developed long, pendent leaves.

Distribution: *Zamia* is second only to *Cycas* in the size of its distributional area and is one of only three cycad genera found on both sides of the equator, the others being *Cycas* and *Encephalartos*. *Zamia* is restricted to the Americas and ranges from Georgia and Florida, south through Mexico, the West Indies, and Central America, into South America as far south as northern Chile, Bolivia, and Brazil.

The genus *Zamia* reaches its greatest diversity in Panama, Colombia, and Cuba. There, *Zamia* has adapted to a multitude of environments, evolving into no fewer than 26 distinct species. It appears probable that several more species may be described from this geographical area. The identification of undescribed species is important as it enables conservation efforts to be directed where they are needed most.

It is strange that in spite of the multitude of forms of *Zamia,* it is not more popular in gardens and private collections. The reason for the lack of large collections of this genus is that almost all zamias are tropical. This limits collections of zamias either to botanical gardens in tropical countries or to institutions with an abundance of greenhouse space. Little has been done in botanical gardens in the Tropics to build large collections of zamias, and I have yet to find any institution with unlimited greenhouse space. It is for lack of space that only representative species are usually found in such collections. Large, complete collections just do not exist. This is unfortunate because the genus *Zamia* is one of the most endangered of the cycads. There is a good possibility that numerous species have become extinct before they were ever discovered and botanically described. It is well known that many species of *Zamia* have a very restricted range. Add to that the rapid rate at which land is being cleared throughout Central and South America and the outcome is all too clear. If action is not taken to ensure their continued existence, many species will be lost forever. In more recent times, laws have been passed by governments to protect these and other endangered species. Foremost among such measures is the Convention on the International Trade in Endangered Species of Wild Flora and Fauna, CITES. All species of *Zamia* are listed in Appendix II of CITES. As well meaning as this agreement is, it has proved to be counterproductive in many instances and has created so much red tape that scientific collecting permits are as difficult to obtain as a commercial permit to export plants by the ton. To work to the benefit of the cycads, this system must be modified to exclude small numbers of plants—not commercial quantities—for use in taxonomic study and propagation.

Zamia acuminata Ørsted ex Thiselton-Dyer 1883b

PLATE 424

The epithet for *Zamia acuminata* is derived from *acuminatus,* Latin and meaning to taper gradually or abruptly from inwardly curved sides to a narrow point, referring to the shape of the leaflets. Chromosome number $2n = 24$. STEMS subterranean, cylindrical, 24–36 cm (9.4–14 in) long, 2.5–6 cm (1–2.4 in) in diameter, leaf bases not persistent and are soon shed, leaving an irregular, more or less smooth, light tan epidermis. LEAVES usually 1–5, rarely as many as 10, glossy medium green, 63–85 cm (25–34 in) long, 26–34 cm (10–13 in) wide, emergent leaves densely light tan tomentose, becoming glabrous with age. Petiole 15.5–25 cm (6.1–10 in) long, 3–5 mm (to 0.2 in) in diameter, moderately armed from base to first leaflets, rarely above. Rachis terminating in a spine 5 mm (0.2 in) long. Leaflets in 10–14 pairs, 15–20 cm (6–8 in) long, 2.5–3.5 cm (1–1.4 in) wide, margins entire and slightly revolute, rarely with a few small teeth on both margins in the apical area, very gradually acuminate to a fine point. FEMALE CONES solitary, rarely two, cylindrical, 14–16 cm (5.5–6.3 in) long, 4.5–5.5 cm (1.8–2.2 in) in diameter, densely light brown tomentose, with a conical cap of sterile sporophylls. Peduncle 22–30 mm (0.9–1.2 in) long, 12–16 mm (0.5–0.6 in) in diameter, densely brown tomentose. Sporophylls 19–24 mm (0.8–0.9 in) long. Sporophyll face hexagonal, flat, 11–18 mm (0.4–0.7 in) high, 18–23 mm (0.7–0.9 in) wide, the facets distinct, the terminal facet slightly sunken. Sarcotesta pinkish red to red when ripe, reported as medium brown in plants from Nicaragua. Sclerotesta irregularly ovoid, 13–20 mm (0.5–0.8 in) long, 8–10 mm (0.3–0.4 in) in diameter, light tan, smooth. MALE CONES one to five, long conical, 5–12.5 cm (2–4.9 in) long, 15–22 mm (0.6–0.9 in) in diameter, densely light brown tomentose, apex blunt, composed of reduced sporophylls. Peduncle 2–2.5 cm (0.8–1 in) long, 7–10 mm (0.3–0.4 in) in diameter, brown tomentose. Sporophyll face hexagonal, 3–4 mm high, 4–6 mm (0.2 in) wide, projecting about 2 mm, densely tomentose except for its edges, the upper and lower facets distinct, the terminal facet so narrow that it appears knife edged or wedge shaped. Sporangia covering the lower surface and sides of the sporophyll, sometimes joining over the top. HABITAT: Wet, low-elevation rain forest (?) in Nicaragua, to seasonally dry, tropical deciduous forest at an elevation of about 1200 m (3900 ft) in Panama, growing as an understory plant and preferring well-shaded steep slopes and ridges. DISTRIBUTION: Nicaragua and Costa Rica, along the Río San Juan. Panama, Coclé province, El Valle de Anton.

Zamia acuminata was described in 1883 by William T. Thiselton-Dyer from plants collected by the Danish botanist and zoologist, Anders Sandøe Ørsted, in Nicaragua near sea level along the Río San Juan. This species has also been collected in Costa Rica where it is reported to occur at elevations of 400 m (1300 ft). In Panama it has only been found in the extinct volcanic cone at El Valle de Anton at an elevation of 1200 m (3900 ft). The type specimen of *Z. acuminata* is housed at the herbarium of the Botanical Museum, University of Copenhagen. I have not seen it so cannot comment on the similarity or difference between it and plants from El Valle de Anton, with which I am familiar. It was also stated that the Nicaraguan plants had seeds with a "medium brown" sarcotesta rather than the orange-red of the Panamanian population. Considering the habitat differences and the spatial separation of approximately 500 km (300 miles), it seems doubtful to me that these two colonies could be the same species. Additional field studies will have to be done to address this.

Speaking only about *Zamia acuminata* originating in Panama, I can recommend it as a superior small *Zamia* for pot or garden culture. The short, decorative leaves and small stature make it an excellent addition to any collection. The plants are undemanding and easy to grow, including coning, in conservatory, tropical, or subtropical conditions. The cones are very decorative but somewhat difficult to pollinate. The males shed their pollen quickly and must be watched closely in order to collect it. The females have a short period of receptivity and often open vertical rather than horizontal cracks, which are easily overlooked.

The conservation status of *Zamia acuminata* is insufficiently known. I have seen two populations near El Valle de Anton, Panama, one large and reproducing, the other small and being reduced by land clearance. I have not been able to locate anyone knowledgeable about the status of the Nicaraguan or Costa Rican populations. It will be impossible to assess the conservation status until it can be determined if these populations are all the same species. We do know that *Z. acuminata* is suffering from habitat loss and for this reason we must consider it threatened.

Zamia amazonum D. W. Stevenson in Stevenson & Sabato 2001

The epithet for *Zamia amazonum* refers to the broad distribution of this species throughout the upper Amazon. Chromosome number not known. STEMS subterranean, tuberous, 3–8 cm (1.2–3.2 in) in diameter. Cataphylls triangular basally, linear lanceolate apically, 3–8 cm (1.2–3.2 in) long, 1–2 cm (0.4–0.8 in) wide. **Leaves** generally two to six, oval to elliptical, to 2.5 m (8.2 ft) long. Petiole 0.5–1 m (1.6–3.3 ft) long, densely armed with small to stout, sometimes branched prickles, densely tomentose when newly emergent. Petiole 0.5–1 m (1.6–3.3 ft) long, armed with prickles in the lower third. Leaflets in 6–12 pairs, papery, oblong lanceolate to lanceolate, apex acuminate, median leaflets 15–20 cm (6–8 in) long, 2–4 cm (0.8–1.6 in) wide, margin flat and finely toothed in the upper half of the leaflet. **Female cones** solitary, 10–15 cm (4–6 in) long, 3–5 cm (1.2–2 in) in diameter, dark red brown tomentose. Peduncle 5–8 cm (2–3.2 in) long. Sarcotesta red. Sclerotesta ovoid, about 10 mm (0.4 in) long and 5 mm (0.2 in) in diameter. **Male cones** two to six, cylindrical, 6–10 cm (2.4–4 in) long, 1–2 cm (0.4–0.8 in) in diameter, brown tomentose. Peduncle 8–15 cm (3.2–6 in) long. **Habitat:** Lowland primary rain forest. **Distribution:** Reported to occur in the Amazonian areas of Venezuela, Colombia, Peru, and Brazil.

The range of *Zamia amazonum* has been given by Dennis W. Stevenson as including the Amazonian areas of Brazil, Peru, Colombia, and Venezuela. If that is correct, *Z. amazonum* is doubtless the most widespread South American species of the genus. It is a reasonably large cycad, with upright leaves reaching a maximum height of about 2.5 m (8.2 ft). It would probably appear somewhat similar to a large plant of *Z. muricata,* though that species forms multiple heads and dense clumps. *Zamia amazonum* can be considered an interesting plant but without a great deal of decorative potential for landscape use.

There is no information available on the cultivation of *Zamia amazonum,* but it should grow well in any subtropical to tropical environment, or under greenhouse culture. Since this species is not what one would call beautiful, or even interesting, it will probably not be of much use as an ornamental. *Zamia amazonum,* if its geographic range is correct, must be considered as not threatened.

Zamia amblyphyllidia D. W. Stevenson 1987

PLATES 425, 426

The epithet for *Zamia amblyphyllidia* is derived from *amblys,* Greek for blunt, and *phyllon,* leaf, and referring to the obovate leaflets. Chromosome number $2n = 16$. **Stems** subterranean, tuberlike, to 15 cm (6 in) long and 6 cm (2.4 in) in diameter, younger plants with a single crown, older plants dividing at the apex to form multicrowned clumps, the old leaf bases and cataphylls soon shed, producing a smooth skin. Cataphylls triangular, stipulate, densely tomentose on the outside. **Leaves** usually three to eight, erect to spreading, glabrous, 0.7–1.5 m (2.3–4.9 ft) long, 30–60 cm (12–24 in) wide. Petiole 30–70 cm (12–28 in) long, 5 mm (0.2 in) in diameter, unarmed. Median leaflets obovate, 15–30 cm (6–12 in) long, 2–6 cm (0.8–2.4 in) wide, margin flat to slightly revolute and serrate in the apical quarter. **Female cones** solitary, ovoid to short cylindrical, 13–14 cm (5.1–5.5 in) long, 5–8 cm (2–3.2 in) in diameter, densely red-brown to dark maroon tomentose, apex apiculate or conical. Peduncle 35–50 mm (1.4–2 in) long, 10–12 mm (0.4–0.5 in) in diameter, densely tomentose. Sporophylls 23–30 mm (0.9–1.2 in) long. Sporophyll face 20–22 mm (0.8–0.9 in) high, 26–31 mm (1–1.2 in) wide, densely tomentose, the facets distinct. Sarcotesta red-orange to orange when ripe. Sclerotesta subglobular to ovoid, 15–20 mm (0.6–0.8 in) long, 13–15 mm (0.5–0.6 in) in diameter, tan, smooth except for about six indistinct longitudinal grooves. **Male cones** one to several, erect until the pollen is shed, 8–12 cm (3.2–4.7 in) long, 16–20 mm (0.6–0.8 in) in diameter, densely dark maroon tomentose. Peduncle 8–25 mm (0.3–1 in) long, 3–7 mm (to 0.3 in) in diameter. Sporophylls 8–10 mm (0.3–0.4 in) long. Sporophyll face hexagonal, 3–5 mm (to 0.2 in) high, 5–8 mm (0.2–0.3 in) wide. Sporangia in two patches. **Habitat:** Steep limestone hills, called mogotes, under cover of trees, among limestone rocks. Rainfall averages 1500 mm (59 in) annually, normally falling during summer. The habitat is wet and relatively warm with high temperatures about 35°C (95°F) and lows about 10°C (50°F). **Distribution:** Puerto Rico, forest of the Río Abajo, Utuado.

The handsome *Zamia amblyphyllidia* was known for many years as *Z. latifoliolata* (= *Z. pumila*). The confusion was brought about by the name *latifoliolata,* broad leaflets, which aptly describes the Puerto Rican *Z. amblyphyllidia.* Taxonomic research has disclosed that *Z. latifoliolata* was described from specimens collected in the Dominican Republic, on the island of Hispaniola, and is a synonym of *Z. pumila.* In 1987 Dennis W. Stevenson described the broad-leafleted Puerto Rican *Z. amblyphyllidia.* In his discussion of the new species, he stated that it also occurs in Jamaica and western Cuba. I have not seen the Cuban specimens, but I have grown the Jamaican *Zamia* for many years. The extremely leathery character of the leaflets of the Jamaican plants is in distinct contrast to the broader, papery leaflets of the described type of *Z. amblyphyllidia* from Puerto Rico. The Jamaican plants have lighter colored, larger female and male cones than *Z. amblyphyllidia.* Additional study, including more fieldwork, is definitely needed, of these taxa as well as many of the other West Indian zamias.

Zamia amblyphyllidia often produces tubers with multiple crowns. This feature is common in older plants of both sexes. Leaf length and width are variable with some populations producing leaves to 1.5 m (4.9 ft) long whereas elsewhere the maximum length may only be 0.7 m (2.3 ft). Light intensity can have a dramatic effect on the length and width of both leaves and leaflets.

Zamia amblyphyllidia grows well in cultivation with a minimum of effort. When mature plants of both sexes are available, seed can be produced quite easily by hand pollination. Fresh seed must be held 3–8 months before planting as the embryo is not well developed at the time seed is shed. Coning plants may be grown from seed in as little as 3 years. *Zamia amblyphyllidia* has reasonable cold tolerance and will take short periods of frost without leaf damage if grown under cover. The tuber should always be planted completely underground to protect it in areas receiving frost. That way, frost damage will generally be restricted to defoliation, which is only temporary as new leaves are usually produced as soon as warm weather returns.

From all reports, *Zamia amblyphyllidia* is still relatively common and regeneration good. Some habitat has been lost through road building and land clearance, but in spite of that, it appears as though *Z. amblyphyllidia* is not immediately threatened.

Zamia amplifolia hort. ex Masters 1878

PLATES 15, 427–429

The epithet for *Zamia amplifolia* is derived from *amplus,* Latin for ample or large, and *folium,* leaf referring to the large leaflets. Chromosome number not known. **Stems** subterranean tubers or sometimes partially exposed, to 76 cm (30 in) long and usually reclining at this size, 10–12 cm (4–4.7 in) in diameter, rarely branching except where damaged, leaf bases and cataphylls not persistent. **Leaves** usually one or two, rarely three or more, 1.3–2.1 m (4–6.9 ft) long, 71–81 cm (28–32 in) wide. Petiole 55–64 cm (22–25 in) long, heavily armed up to the leaflets but usually not beyond them. Leaflets in two to eight pairs, glossy bright green, 30–42 cm (12–17 in) long, 7.5–11.5 cm (3–4.5 in) wide, veins depressed above and raised below, margin entire. **Female cones** solitary, barrel shaped, 20–30 cm (8–12 in) long, 8–10 cm (3.2–4 in) in diameter, densely cream to tan tomentose. Sclerotesta ovoid, 10–15 mm (0.4–0.6 in) long, 6 mm (0.2 in) in diameter. **Male cones** solitary, cylindrical, 4–9.5 cm (1.6–3.7 in) long, 1–2.5 cm (0.4–1 in) in diameter, densely yellowish tan tomentose, apex of reduced sporophylls. Peduncle about 4 cm (1.6 in) long and 1 cm (0.4 in) in diameter. Sporophyll face about 3 mm in diameter, the terminal facet distinct and slightly sunken. **Habitat:** Wet coastal rain forest, from near sea level to 800 m (2600 ft), generally in black clay soil with abundant organic material. Rainfall averages 6000–8000 mm (240–320 in) annually, falling throughout the year. The climate is warm to hot all year with summer and winter highs above 30°C (86°F). **Distribution:** Colombia, Cauca, Valle de Cauca, and Chocó departments, in the catchment area of the Río Calima and on the Old Road from Cali to Buenaventura.

Although described in 1878, *Zamia amplifolia* has been misidentified by most of its collectors. Because of its corrugated leaflets, it has been mistaken for *Z. neurophyllidia* of Costa Rica and Panama, and *Z. skinneri* of Panama. *Zamia amplifolia* is quite distinct from these northern relatives because of its fewer leaves, leaflets with entire margins, and much smaller stem.

The area around the town of Bajo Calima, Valle de Cauca, Colombia, supports great numbers of *Zamia amplifolia* as well as *Z. chigua.* The entire area has been drastically logged but the zamias seem to have survived this demolition of the forest. There they grow in fair numbers in what remains of their original habitat. This area is of particular interest as there has been large-scale hybridization between these two endemic species (Plates 15–18). A more confusing array of plants could not be imagined. One finds *Z. chigua* with long, narrow, smooth-margined leaflets, *Z. amplifolia* with broad, corrugated, serrate-margined leaflets, and an assortment of every conceivable combination of the two. It is the only cycad locality I know of where hybridization of this magnitude has taken place.

There is no doubt that great numbers of *Zamia amplifolia* have been destroyed during the logging operations that have affected a large portion of its habitat. In spite of this destruction, many of the zamias have survived and have grown well in the secondary vegetation that now covers the area. Reproduction of the cycad in its habitat is rare, and immature plants are scarce. I asked a friend who frequented the locality if he could collect some seeds for me. He replied that he would be pleased to do so if he ever saw any, but in all the years that he had traveled in the area not a single cone had been seen!

Zamia amplifolia is an interesting cycad but somewhat difficult to cultivate. In its habitat it sometimes grows in muck, but in cultivation it will develop root rot if not provided with proper drainage. It may be grown in tropical climates or in a greenhouse that provides the needed warmth and humidity during the winter months. The remarks about *Z. chigua* in regard to possible soil requirements apply to this species as well.

Zamia amplifolia must be considered threatened. This cycad has been able to survive the almost complete destruction of its habitat, but regeneration is almost nonexistent. No juvenile plants were seen over the entire area surveyed. The lack of seeds or seedlings is mute evidence that this species must be declining.

Zamia angustifolia Jacquin 1791

PLATE 430

Zamia stricta Miquel 1851

Zamia angustifolia, the epithet derived from *angustus,* Latin for narrow, and *folium,* leaf, referring to the exceedingly narrow leaflets, is called bay rush. Chromosome number $2n = 16$. **Stems** subterranean, tuberous, spindle shaped, rarely with the crown exposed and then probably the result of erosion, to 20 cm (8 in) long and about 7.5 cm (3 in) in diameter. As a rule, mature coning-size plants are generally smaller. Stems are usually single headed, but some naturally branching plants occur whereas others are branched as a result of damage to the crown. **Leaves** usually five to seven, slightly arched, when growing in sun about 52 cm (20 in) long, 12.5 cm (5 in) wide, strongly keeled, not flattened, upright, when growing in shady conditions about 78 cm (31 in) long, 34 cm (13 in) wide, flat, with leaflets held at an angle of about 90° to the rachis. Petiole subterete, brownish green, slightly flattened above where leaflets attach, 14–19 cm (5.5–7.5 in) long, 3 mm in diameter, unarmed. Leaflets angled forward about 45°, the apical three pairs slightly reduced in length, median leaflets about 11.5 cm (4.5 in) long and 2 mm wide, spaced about 25 mm (1 in) apart, sometimes slightly falcate and very gradually acuminate, ending in a narrow blunt point, often with one to three small teeth at the apex, the surface flat, dark green except for a pinkish callus at the attachment, the insertion slightly above the center of the rachis. **Female cones** solitary, about 9 cm (3.6 in) tall and 5 cm (2 in) in diameter, with a short blunt sterile cap. Peduncle 2.5 cm (1 in) tall, 1 cm (0.4 in) in diameter. Sporophylls 18–19 mm (0.7 in) long, light tan tomentose. Sporophyll face 6–8 mm (0.2–0.3 in) high, 16–21 mm (0.6–0.8 in) wide, the terminal facet slightly sunken, it and the area immediately around it dark brown. Sarcotesta red-orange when ripe. Sclerotesta subglobose, 12–16 mm (0.5–0.6 in) long, 10–13 mm (0.4–0.5 in) in diameter, light tan, the surface smooth. **Male cones** usually solitary but may be as many as three per crown, 9–13 cm (3.5–5.1 in) long, 2.5 cm (1 in) in diameter, densely tomentose, tan with darker brown terminal facets. Peduncle 4–5.5 cm (1.6–2.2 in) long, 4–5 mm (0.2 in) in diameter, brown and white tomentose. Sporophylls 4 mm high, 6–7 mm (0.2–0.3 in) wide. Sporangia in two patches continuing a short distance over the edges of the sporophyll. **Habitat:** Dry sclerophyll forest in more open areas and forest margins, usually no more than 0.5 km (0.3 mile) from the shoreline on gently rising slopes, in full sun or under tree cover in association with *Agave, Bursera,* and *Tabebuia,* only in areas of red soil mixed with a liberal amount of limestone fragments, at elevations of 2–13 m (6.6–43 ft). Rainfall averages 1100 mm (43 in) annually, of which 800 mm (31 in) falls during summer, May–October. Temperatures are 27–30°C (79–86°F) in summer and average about 21°C (70°F) in winter with occasional lows of 9–10°C (48–50°F). **Distribution:** Bahamas, island of Eleuthera.

Zamia angustifolia without doubt possesses the most remarkable leaflet form to be found in the Bahamian zamias. Its small size coupled with its extremely narrow leaflets set it apart at once from all the others. Only in *Z. angustissima* of Cuba and *Z. spartea* of Mexico does one find other taxa with these distinctive long, narrow leaflets. They are no doubt an adaptation to the hot, dry habitats in which these three cycads grow. In my opinion, *Z. angustifolia* and *Z. angustissima* are distinct species. They are not found to intergrade with any of the other West Indian zamias, and their habitats, though similar, are separated by more than 330 km (200 miles). When Dennis W. Stevenson (1987) reinstated *Z. angustifolia* as a separate species, which had been put in synonymy under *Z. pumila* by James E. Eckenwalder (1980), he did so based on cone color differences. Plants that Stevenson studied at the Fairchild Tropical Garden, Miami, Florida, had both female and male cones with a white to gray background, and black to brown vertical stripes when immature. This he considered the most important factor in separating *Z. angustifolia,* to comprise both the Bahamian and Cuban populations, from the *Z. pumila–Z. integrifolia* complex. It appears that his conclusion may be incorrect. There is a plant in my greenhouse collected by Charles J. Chamberlain in Cuba and labeled *Z. angustissima.* It is a female and its cones do indeed exhibit the vertical black and white striping referred to by Stevenson. On the other hand, *Z. angustifolia* on Eleuthera, Bahamas, observed coning in habitat, and later in cultivation, produced both female and male cones that had a light tan background with dark brown terminal facets. I believe that the Bahamian *Z. angustifolia* and Cuban *Z. angustissima* are distinct.

Long-time residents of Eleuthera remember when *Zamia angustifolia* was collected and used for starch. One old man I questioned said, "it never grows in the white soil areas, but always on red soil." This proved to be true in my survey.

In cultivation, *Zamia angustifolia* grows exceedingly well with a minimum of care. Its small size makes it a fine candidate for growing in pots, and its tolerance for sun allows it to be grown in open situations. This cycad is resistant to cold and will endure some frost without visible damage. As with other subterranean zamias, the tuber should be planted below the soil surface to protect it from freezes. This *Zamia* has a rapid growth rate and seedlings given the proper care will reach coning size in about 3 years. The cones are easily pollinated and take about 9 months to mature. The seed should be stored 5–6 months before planting to allow the embryo to develop.

The distribution of *Zamia angustifolia* is very localized with small colonies found scattered over a large area. Regeneration seems good, and seedlings in various stages of development are fairly common. The land is poor and rocky, but a portion of the habitat is being cleared for growing pineapples. This habitat destruction will lead to reduction of this cycad's range and numbers. Because of its small numbers and restricted distribution on Eleuthera, *Z. angustifolia* must be considered extremely endangered.

Zamia angustissima Miquel 1852

Zamia yatesii Miquel 1861
Zamia multifoliolata A. de Candolle 1868
Zamia guggenheimiana Carabia 1941

The epithet for *Zamia angustissima* is derived from *angustus,* Latin for narrow and meaning very narrow, referring to the leaflets. Chromosome number not known. Stems subterranean, tuberous, 20–25 cm (8–10 in) long, 2.5–5 cm (1–2 in) in diameter. Leaves usually one to five, spreading and arching, green to yellow-green, glabrous, 0.5–1 m (1.6–3.3 ft) long, 30–33 cm (12–13 in) wide, slightly keeled. Petiole round, 20–28 cm (8–11 in) long, 3–4 mm in diameter, unarmed. Leaflets in 25–37 pairs, narrowly linear, straight, leathery, flat to slightly concave, dark green, median leaflets 15–17 cm (6–6.7 in) long, 2–4 mm wide, margin slightly revolute, unarmed. Female cones solitary, erect, 62–75 mm (2.4–3 in) long, 37–50 mm (1.5–2 in) in diameter, emergent cones white to gray, becoming mottled dark brown or black and gray, finally an overall dark gray-brown. Peduncle 25–50 mm (1–2 in) long, 7–10 mm (0.3–0.4 in) in diameter, brown tomentose. Sporophyll face 10–12 mm (0.4–0.5 in) high, 18–23 mm (0.7–0.9 in) wide. Sarcotesta red to red-orange when ripe. Male cones solitary (or more?), erect, 65–75 mm (2.6–3 in) long, 16–20 mm (0.6–0.8 in) in diameter. Peduncle 35–40 mm (1.4–1.6 in) long, 5–7 mm (0.2–0.3 in) in diameter. Habitat: Low-elevation open woodlands and grasslands. Distribution: Cuba, reported from the eastern part of the island near Pilón.

The Cuban *Zamia angustissima* was described by Friedrich Anton Wilhelm Miquel in 1852. It and the other West Indian zamias were placed in synonymy under *Z. pumila* by James E. Eckenwalder (1980), then under *Z. angustifolia* after the reinstatement of that species by Dennis W. Stevenson (1987). I believe that the treatment of the West Indian zamias, by both Eckenwalder and Stevenson, has been oversimplified. The morphological differences, especially in the cones, between *Z. angustifolia* and *Z. angustissima* seem to provide good reason for their separation into two species, as discussed further under *Z. angustifolia.*

There are very few specimens of *Zamia angustissima* in cultivation, therefore not a great deal has been written about their requirements. I have a single plant in my collection that came originally from the Charles J. Chamberlain collection at the University of Chicago. Chamberlain had obtained this specimen when he visited Cuba to study its cycads in the early 1900s. This plant now has multiple crowns and is a female. It has grown well in the greenhouse and produces cones and leaves each year. Because it is my only plant, I have not tried to grow it outdoors. The Bahamian zamias do quite well outdoors in coastal southern California, and I have no doubt that this Cuban species would also be trouble-free. *Zamia angustissima* grows best in bright light or full sun and, of course, in soil with good drainage. Its diminutive size makes *Z. angustissima* a useful plant for small garden areas and border plantings.

The conservation status of *Zamia angustissima* is unknown. None of the Cuban botanical gardens has been able to supply information on its status or on exact localities. Cuba is suffering the same loss of habitat through land clearance that is occurring throughout the Caribbean. With this in mind, we must consider *Z. angustissima* endangered until such time as additional information becomes available.

Zamia boliviana (Brongniart) A. de Candolle 1868

PLATE 431

Ceratozamia boliviana Brongniart 1846

Zamia brongniartii Weddell 1849

The epithet for *Zamia boliviana* refers to Bolivia, this cycad's country of origin. Chromosome number $2n = 16$. **Stems** tuberous, subterranean, cylindrical, about 25 cm (10 in) long, 6–8 cm (2.4–3.2 in) in diameter. **Leaves** usually three to five in mature plants, pale green, glabrous, 40–50 cm (16–20 in) long, about 50 cm (20 in) wide. Petiole terete, glabrous, somewhat triangular in cross section, about 30 cm (12 in) long, unarmed. Leaflets in 10–18 pairs, linear lanceolate, straight or subfalcate, 20–30 cm (8–12 in) long, 1 cm (0.4 in) wide, entire or finely toothed near the apex, with two to five minute teeth on each margin, revolute. **Female cones** solitary, oblong, 14–18 cm (5.5–7.1 in) long, about 5 cm (2 in) in diameter, red-brown tomentose, apiculate, sterile apex about 2 cm (0.8 in) tall. Peduncle 8–10 cm (3.2–4 in) long, about 7 mm (0.3 in) in diameter. Sporophylls in about eight vertical rows of 14–18 each. Sporophyll face 8–10 mm (0.3–0.4 in) high, 10–15 mm (0.4–0.6 in) wide, the facets indistinct, slightly depressed in the center. Sarcotesta scarlet when ripe. Sclerotesta oblong elliptical, about 12 mm (0.5 in) long. **Male cones** solitary, cylindrical, 5–7 cm (2–2.8 in) long, 10–13 mm (0.4–0.5 in) in diameter, tomentose. Peduncle 2.5–8 cm (1–3.2 in) long, about 5 mm (0.2 in) in diameter. Sporophylls hexagonal, the facets more or less well defined, tomentose, ground color tan, the area of the terminal facet medium brown. Sporophyll face 3–4 mm high and wide. Sporangia in two patches on the top and sides of the sporophyll. **Habitat:** In association with caudiciforms and grasses at an elevation of about 170 m (560 ft). The climate is reported to be somewhat dry. **Distribution:** Bolivia, reported from the vicinity of Beni in Beni department and Chiquitos in Pando department.

Zamia boliviana is seldom seen in botanical gardens or private collections. Information on the species is scant, and very little is known about its preferences in cultivation. It is not a very striking cycad and therefore has never been sought after by collectors. One would expect it to require well-drained soil that does not hold excessive moisture, and periodic applications of a balanced fertilizer. This species probably is not frost tolerant.

Nothing is known about the conservation status of *Zamia boliviana,* but the clearing of land in Bolivia must eventually have an adverse effect on this cycad's survival. Therefore, it must be considered threatened.

Zamia chigua Seemann 1852

PLATES 16, 432, 433, 469

Zamia chigua, the epithet the common name used by some Central and South American Indians for zamias, is also called *chigua macho* or, in Spanish, *helecho,* fern. Chromosome number $2n = 16$. **Stems** cylindrical, usually unbranched but sometimes branched as a result of injury, 1–2 m (3.3–6.6 ft) long, to 15 cm (6 in) in diameter, in older plants the leaf bases shed and replaced with a smooth, light tan skin sometimes wrinkled in appearance. **Leaves** usually 5–15, light green, 1.5–3 m (4.9–10 ft) long, 34 cm (13 in) wide, flat. Petiole 30–100 cm (12–40 in) long, densely covered with prickles, and swollen at the base. Rachis terete, arching, prickly, apex ending in a point extending about 3 cm (1.2 in) beyond the terminal leaflets. Leaflets in 60–108 pairs, lanceolate, falcate, jointed at the rachis by a distinct articulation near which the leaflet is so narrowed as to be semicircular, median leaflets 10–30 cm (4–12 in) long, 1–1.8 cm (0.4–0.7 in) wide, alternate or opposite, at nearly right angles to the rachis, somewhat overlapping at the widest point, nearly the same length and size throughout the entire leaf, very gradually acuminate to a long, narrow apex, margin entire. **Female cones** solitary, 20–30 cm (8–12 in) long, 8–12 cm (3.2–4.7 in) in diameter, light brown tomentose. Peduncle about 5 cm (2 in) long, covered with short hairs. Sarcotesta red to scarlet when ripe. Sclerotesta ovoid, 3–3.5 cm (1.2–1.4 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, smooth. **Male cones** usually one to three, nearly cylindrical, 19–21 cm (7.5–8.3 in) long, 2–3 cm (0.8–1.2 in) in diameter, converging suddenly into a conical cap at the cone apex, the conical part not solid but consisting of small abortive sporophylls. Peduncle 6–8 cm (2.4–3.2 in) long, 1.5 cm (0.6 in) in diameter. Median sporophylls distinctly hexagonal, covered with short brown tomentum. Sporangia only on the sides of the sporophylls with a wide sterile area both above and below. **Habitat:** Coastal rain forest and river margins at elevations of 10–150 m (33–500 ft). Rainfall averages 6000–8000 mm (240–320 in) annually. Temperatures average 24°C (75°F) with summer highs above 30°C (86°F), and humidity about 85%. **Distribution:** Colombia, Chocó department, from Cabo Corrientes in the north to the Río San Juan in the south; Cauca department, between the Río San Juan and Río Calima.

Around the mouth of the Río San Juan in Colombia, two species of *Zamia* occur, *Z. chigua* and *Z. roezlii.* The Indian names for the former are *chigua macho* (male *chigua*) and *helecho* (fern), for the latter, *chigua.* Berthold Seemann described *Z. chigua* in 1852 from material he collected in

1847 during the voyage of H.M.S. *Herald.* In 1873 Jean Jules Linden described *Z. roezlii* from a plant growing in his garden that had been collected by Benedikt Roezl on the "Pacific coast of South America." In later years, when collectors went to the mouth of the Río San Juan for *Z. chigua,* the only cycad they found was the one the Indians called *chigua.* It was taken for granted that they had the correct plant. Numerous plants and seeds were collected and distributed as *Z. chigua* that were really *Z. roezlii.* This misapplication of names went on until Robert L. Dressler read Seemann's account of the voyage of H.M.S. *Herald,* in which *Z. chigua* was described and illustrated. It immediately became clear that the cycad that had been grown for years as *Z. chigua* was in fact *Z. roezlii.* The two species are easily distinguished as *Z. chigua* has slender, light green, smooth leaflets whereas *Z. roezlii* has broad, corrugated leaflets with deeply sunken veins.

Zamia chigua is a handsome cycad with a treelike trunk to 2 m (6.6 ft) tall and holding numerous bright green leaves made of many long, narrow, falcate leaflets. In the jungle it is a beautiful sight, growing on a riverbank or buried in the forest. In habitat it will grow in muck, something it will not tolerate in cultivation. The Indians often plant the cycads around their huts by simply cutting them off with a machete and placing the stem in a shallow hole.

In cultivation, *Zamia chigua* requires a warm subtropical to tropical climate and partial shade. The cycad is from a very wet habitat and requires a continually damp potting mix and high humidity. Plants will suffer considerable damage or die if their potting soil is allowed to dry out. *Zamia chigua* has proved to be somewhat difficult to maintain in good condition in cultivation. Not only are the plants frost sensitive, they also strongly resent any temperature below 10°C (50°F). In its habitat the yearly average temperature is 24°C (75°F) and the average humidity 87.6%. The highest annual average humidity for any year was 90.5% in 1985, the lowest 85.1% in 1976. Annual rainfall averages 6000–8000 mm (240–320 in). When I was doing fieldwork in this cycad's habitat I remember hearing what I thought was the approach of a jet airliner only to find that it was the noise of an approaching rainstorm! Another possible problem with *Z. chigua* in cultivation is the composition of the soil. Soils in the region of its habitat are extremely poor in boron, phosphorus, and zinc. In addition, the levels of calcium, copper, magnesium, manganese, and potassium are quite low but the soil is saturated with aluminum. Soil pH ranges from 4.3 to 5.0. I have not had time to experiment with soil mixes to try and duplicate the habitat soil, but I feel it might make the difference necessary to grow this *Zamia* properly.

The conservation status of *Zamia chigua* is quite secure. There are numerous plants scattered over an extensive range, which at present is not being cleared rapidly. A rating of not threatened seems sufficient.

Zamia cremnophila Vovides, Schutzman & Dehgan in Schutzman et al. 1988

PLATES 434–436

The epithet for *Zamia cremnophila* is derived from *cremnos,* Greek for cliff, and *philo-,* loving, and meaning cliff loving, referring to this cycad's unusual habitat preference. Chromosome number $2n = 16$. **Stems** subterranean or sometimes growing exposed from cracks in cliffs, unbranched, sometimes erect but usually decumbent or somewhat pendent, 10–25 cm (4–10 in) long, 3–9 cm (1.2–3.5 in) in diameter. Cataphylls elongate, triangular, stipulate, tomentose, 37–43 mm (1.5–1.7 in) long, 12–14 mm (0.5–0.6 in) wide at base. **Leaves** one to several depending on the size and condition of the plant, pendent, 1–2 m (3.3–6.6 ft) long, 41–72 cm (16–28 in) wide. Petiole 45–60 cm (18–24 in) long, 1–1.3 cm (0.4–0.5 in) in diameter. Petiole and rachis heavily armed, especially the basal portion, petiole base bulbous. Leaflets in 15–25 pairs, long lanceolate to oblong, 10–36 cm (4–14 in) long, 2–4 cm (0.8–1.6 in) wide, deep purplish red during emergence and for a considerable time afterward, at maturity green, leathery, glabrous, overlapping except in deep shade, the attachment to the rachis 8–12 mm (0.3–0.5 in) wide. **Female cones** solitary, cylindrical, barrel shaped, 8.5–14 cm (3.3–5.5 in) long, 5.5 cm (2.2 in) in diameter, dark brown tomentose, with an acuminate apex. Peduncle 4–5 cm (1.6–2 in) long, 1.5 cm (0.6 in) in diameter, lightly brown tomentose. Sporophyll face hexagonal truncate, 11–16 mm (0.4–0.6 in) high, 16–26 mm (0.6–1 in) wide, the terminal facet sunken and narrowed horizontally, 7–10 mm (0.3–0.4 in) long, 2–3 mm wide. Sarcotesta bright scarlet when ripe. Sclerotesta ovoid, 15–17 mm (0.6–0.7 in) long, 9–10 mm (0.4 in) in diameter, light tan, smooth. **Male cones** usually solitary, rarely two or three, cylindrical to conic, 8–11 cm (3.2–4.3 in) long, 22–25 mm (0.9–1 in) in diameter, light brown tomentose. Peduncle tomentose, 25–30 mm (1–1.2 in) long, 8 mm (0.3 in) in diameter. Sporophyll face hexagonal truncate, 3–4 mm high, 5–7 mm (0.2–0.3 in) wide, the facets indistinct except for the distinctly concave terminal one. Sporangia in two patches separated by a space about 2 mm wide. **Habitat:** Rocky, more or less vertical cliff sides on limestone hills, called mogotes, heavily covered by rain forest. Rain falls in summer, and the winters are generally dry. Low light intensities and a hot, humid climate prevail. **Distribution:** Mexico, Tabasco state, between Teapa and Tapijulapa.

In early 1985, Andrew P. Vovides, Bart Schutzman, and Bijan Dehgan were studying specimens in the herbarium at Mérida, Yucatán, Mexico. They noted that one specimen seemed to be quite different and proceeded to locate the plant in its habitat. Their investigation proved that this cycad was distinct, leading to its description as *Zamia cremnophila* in 1988. *Zamia cremnophila* is almost as distinctive in the genus as *Z. pseudoparasitica* in that both have evolved highly specialized habitat preferences. *Zamia pseudoparasitica* grows as an epiphyte in trees, and *Z. cremnophila* on sheer cliffs. Both species have developed long, flexible, pendent leaves well suited to their habitats. One wonders what the dispersal agents are for these species. There is a strong possibility that fruit bats or birds play a role in the seed transport of each. Additional studies in the field may disclose the clues needed to solve this mystery.

The closest relatives of *Zamia cremnophila* are *Z. lacandona, Z. purpurea,* and *Z. splendens.* The three are easily distinguished from *Z. cremnophila* as all grow on more or less level ground and have upright rather than pendent leaves. I have investigated a *Zamia* that grows in the mountains south of La Ceiba, Honduras, that is closely related to *Z. cremnophila* and that deserves further study.

Zamia cremnophila is rare in collections as a result of its somewhat restricted cliffside home and its scattered distribution. In cultivation, *Z. cremnophila* is easily grown if given well-drained soil and sufficient warmth. Like other highly specialized cycads, it is surprising how adaptable it has proved to be in cultivation. It is hoped that artificial propagation of the plants in cultivation will make it easier to obtain this cycad.

Because of its wide distribution, the impossibility of using its habitat for livestock or crops, and the difficulty of access to its cliffsides, *Zamia cremnophila* is not classified as threatened.

Zamia cunaria Dressler & D. W. Stevenson in Stevenson 1993

PLATES 437, 438

Zamia cunaria, the epithet referring to the Cuna Indians who inhabit the area where this cycad is found, is called *obset* by Cuna Indians, the female cone called *obset e sana.* Chromosome numbers $2n$ = 23, 24. **Stems** subterranean, subglobose, to 10 cm (4 in) in diameter. Cataphylls occurring in two forms, those produced prior to coning 7–10 cm (2.8–4 in) long, 2–3 cm (0.8–1.2 in) wide, those produced before leaves the same width but 3–4 cm (1.2–1.6 in) long. **Leaves** usually one to three, 0.5–1.5 m (1.6–4.9 ft) long, 32–65 cm (13–26 in) wide. Petiole 15–50 cm (6–20 in) long, sparsely to densely armed. Leaflets in 3–12 pairs, median leaflets broad lanceolate, 20–40 cm (8–16 in) long, 5–8 cm (2–3.2 in) wide, apex acuminate, margin flat and serrate in the apical third. **Female cones** solitary, cylindrical to long ovoid, 15–20 cm (6–8 in) long, 5–7 cm (2–2.8 in) in diameter, densely wine red to dark red-brown tomentose, apex with a sterile cap. Peduncle 2–3 cm (0.8–1.2 in) long, 1.5 cm (0.6 in) in diameter. Sporophyll face about 5 mm (0.2 in) high and 10 mm (0.4 in) wide. Sarcotesta pink to light red when ripe. Sclerotesta ovoid to long ovoid, 15–20 mm (0.6–0.8 in) long, 5–8 mm (0.2–0.3 in) in diameter, tan, smooth. **Male cones** solitary, cylindrical to long ovoid, 4–6 cm (1.6–2.4 in) long, 1–1.5 cm (0.4–0.6 in) in diameter, densely cream to tan tomentose. Peduncle 2–4 cm (0.8–1.6 in) long, 8– 10 mm (0.3–0.4 in) in diameter. Sporophylls tomentose. Sporophyll face with six steeply inclined facets surrounding a centrally depressed terminal facet. Sporangia present on upper and lower surfaces of the sporophyll. **Habitat:** Clay soils on steep slopes and ridge tops at elevations of 400–800 m (1300–2600 ft) in primary rain forest and secondary vegetation. Rainfall averages 2000 mm (79 in) annually, generally falling April–December. The annual temperature averages 25°C (77°F). **Distribution:** Panama, Comarca de San Blas territory, Cuna Yala, the area of the Cuna Indians in northern central Panama.

Discovered by Robert L. Dressler and described as recently as 1993, a few specimens of *Zamia cunaria* have been in cultivation at the Missouri Botanical Garden, St. Louis, since about 1980. The Cuna Indians are said to use the seed to make necklaces, and the plant is used as food. *Zamia cunaria* is very similar to *Z. ipetiensis,* which grows roughly 70 km (43 miles) east and at a slightly lower elevation. The distinguishing features of the two species are compared under *Z. ipetiensis.*

The plants grow well if given a loose mix and protected from cold weather. Growing requirements do not differ from those of other Central or South American species of *Zamia,* which occur in a semitropical to tropical climate. In habitat, an average *Z. cunaria* holds only one to three leaves. In cultivation, because of the constant availability of water and nutrients, about twice as many can be expected.

The exact conservation status of *Zamia cunaria* is not known but the cycad is presumed to be threatened. Logging and clearing of the rain forest goes on unchecked, and this species' habitat is gradually being destroyed (Plate 27). On the positive side is the fact that *Z. cunaria* has a subterranean stem, giving it considerable protection during land clearance, and plants can be found growing in cleared areas in even better health than their rain forest counterparts.

Zamia cupatiensis Ducke 1922

PLATE 439

Zamia cupatiensis, the epithet referring to the Cerro de Cupati, now Cerro de la Pedrera, is called *koo-roó-chee* by Yukuna Indians. Chromosome number not known. STEMS subterranean or sometimes with the tuber exposed in shallow soils or as a result of erosion, unbranched except because of injury. LEAVES usually one to four, 35–55 cm (14–22 in) long, 42 cm (17 in) wide. Petiole 20–30 cm (8–12 in) long, unarmed. Leaflets in four to nine pairs, 15–21 cm (6–8.3 in) long, 4–6 cm (1.6–2.4 in) wide, ovate lanceolate, narrowed toward apex and base, inserted at right angles to the rachis, with 30–34 veins, margin revolute and entire except for a single fine tooth at the apex. FEMALE CONES solitary, erect, subcylindrical, 5–6 cm (2–2.4 in) long, 3–3.5 cm (1.2–1.4 in) in diameter, brownish purple tomentose. Peduncle 4–5 cm (1.6–2 in) long. Sporophylls in vertical series of six to eight. Sporophyll face hexagonal, about 8 mm (0.3 in) high and 18 mm (0.7 in) wide. Sarcotesta red when ripe. Sclerotesta ovoid, about 3 cm (1.2 in) long and 2 cm (0.8 in) in diameter, smooth. MALE CONES one or two (or more?), erect, 4–8 cm (1.6–3.2 in) long, 1.5–3 cm (0.6–1.2 in) in diameter, yellowish gray. Sporophylls about 4 mm in diameter, in vertical series of 10. HABITAT: Humid forest, preferring the tops of huge boulders covered with a thin layer of sand, lichens, and decaying organic material, 330–430 m (1100–1400 ft) above the forest floor. DISTRIBUTION: Colombia, Amazonas department, Río Caqueta, Cerro de la Pedrera (Cerro Cupati), known only from near the summit of the small, isolated mountain rising out of the plains in extreme southeastern Colombia, close to the border with Brazil.

Zamia cupatiensis was discovered in 1912 by the eminent Brazilian authority on the flora of the Amazon, Adolpho Ducke. In his original description he stated that part of the swollen stem is exposed and grows above the surface of the ground. When Richard Evans Schultes (1953) wrote about this species, he was of the opinion that the exposed tuber was caused by "extremely sparse soil or sand on certain parts of the mountain and does not represent a truly natural characteristic of the plant." Since most of the small zamias usually produce a subterranean tuber, Schultes's observation is probably valid. An interesting comment made by Schultes was that this *Zamia* seems to prefer the tops of huge boulders covered with a thin layer of sand, lichens, and decaying organic material. He also stated that he did not find the cycad growing on the forested slopes where the soil was deeper and moisture more abundant.

Zamia cupatiensis is virtually unknown in cultivation as a result of its remote habitat. I have never seen a live specimen and therefore cannot comment on it. It is probable that living material has only been collected on two or three occasions since its discovery. The illustration in Ducke's original description depicts a very attractive, if somewhat sparsely leaved cycad.

Both Ducke and Schultes stated that *Zamia cupatiensis* was common on Cerro de la Pedrera (Cerro Cupati), common enough that the Yukuna Indians of the region were said to use the tuber in the preparation of a starchy meal or farina for food. The apparent abundance of this species, coupled with its very remote habitat, indicates that it probably is not threatened. One must, however, take into account that the last documented investigation of its habitat was more than 40 years ago.

Zamia disodon D. W. Stevenson & Sabato 2001

PLATE 440

The epithet for *Zamia disodon* is said by Dennis W. Stevenson and Sergio Sabato to refer to the doubly toothed leaflet margins. Chromosome number not known. STEMS subterranean, tuberous, 5–8 cm (2–3.2 in) in diameter. Cataphylls triangular basally, linear lanceolate apically, 3–6 cm (1.2–2.4 in) long, 1–2 cm (0.4–0.8 in) wide. LEAVES generally two to four, erect to curved slightly backward and downward, oblong, about 50 cm (20 in) long, emergent leaves yellowish purple to brownish purple, gradually turning emerald green at maturity. Petiole terete, about 25 cm (10 in) long, lightly armed with small prickles. Rachis terete, about 25 cm (10 in) long, generally unarmed. Leaflets generally in three to five pairs, thin textured, elliptical, subfalcate, the veins prominently raised above, median leaflets 12–20 cm (4.7–8 in) long, 6–10 cm (2.4–4 in) wide, margin serrate, generally with some doubly serrate teeth near the apex of the leaflet. FEMALE CONES not described. MALE CONES approximately 4 cm (1.6 in) long and 1 cm (0.4 in) in diameter. HABITAT: Primary and secondary rain forest, generally in clay soils, at elevations of 400–800 m (1300–2600 ft). DISTRIBUTION: Colombia, Antioquia department and possibly Chocó department, near the border with Panama, possibly extending into southern Darién province, Panama.

Zamia disodon, in my opinion, is probably the most beautiful of all zamias. The broad, thin, glossy, leaflets of *Z. disodon,* coupled with their elevated veins and unusual coloration, add up to make this a most distinctive and elegant cycad. Once a specimen of *Z. disodon* has been seen, it would be very unlikely to mistake it for any other species of the genus. Although one of the diagnostic features presented in the description of *Z. disodon* is the occurrence of doubly toothed margins, in my experience, based on only two specimens, the double serrations are not common and generally only one or two occur on each leaflet, with the majority of the leaflets having none.

In cultivation, *Zamia disodon* requires a subtropical to tropical environment or greenhouse culture. No matter what it requires, it would be worth the trouble to grow this beautiful plant. To my knowledge there are no special requirements for proper cultivation other than a warm, humid atmosphere.

The conservation status of *Zamia disodon* is not adequately known. Only two colonies have been located, one of which has been almost completely eradicated through land clearance for the planting of bananas. Until such time as the investigation of the known range can be completed, *Z. disodon* must be considered extremely endangered.

Zamia dressleri D. W. Stevenson 1993

PLATES 441–443

Zamia dressleri is named in honor of Robert Louis Dressler (b. 1927), botanist and taxonomist at times associated with the Missouri Botanical Garden, St. Louis, who aided in the study of the cycads of Panama. Chromosome number not known. STEMS subterranean, unbranched, 12.5–15 cm (5–6 in) long, 3–6.3 cm (1.2–2.5 in) in diameter. Cataphylls ovate, 1–2 cm (0.4–0.8 in) long, 2–3 cm (0.8–1.2 in) wide. LEAVES usually solitary but sometimes two or three on large, old plants, erect, dark green, 0.5–1.5 m (1.6–4.9 ft) long, 55–90 cm (22–35 in) wide, flat. Petiole 0.3–1 m (1–3.3 ft) long, sparsely to densely armed. Leaflets in two to five pairs, corrugated, median leaflets elliptical, 30–50 cm (12–20 in) long, 12–15 cm (4.7–6 in) wide, margin flat to slightly revolute, serrate in the apical third to half of the leaflet. FEMALE CONES solitary, ovoid cylindrical, 10–15 cm (4–6 in) long, 3–4 cm (1.2–1.6 in) in diameter, wine red to dark red-brown tomentose, apex with a sterile cap. Peduncle 4–6 cm (1.6–2.4 in) long, 2–2.5 cm (0.8–1 in) in diameter. Sporophyll face 11–16 mm (0.4–0.6 in) high, 16–22 mm (0.6–0.9 in) wide. Sarcotesta red when ripe. Sclerotesta ovoid to cylindrical, somewhat three-sided, 15–18 mm (0.6–0.7 in) long, 8–10 mm (0.3–0.4 in) in diameter, smooth. Chalaza obscure, about 1 mm in diameter. MALE CONES usually solitary, cylindrical, 5–8 cm (2–3.2 in) long, 1–2 cm (0.4–0.8 in) diameter, cream to red-brown tomentose. Peduncle about 32 mm (1.3 in) long and 8 mm (0.3 in) in diameter, densely red-brown tomentose. Sporangia in two patches of two rows each, the outer row on the edge of sporophyll. HABITAT: Rain forest or under secondary growth where forest has been cut, from near sea level to about 200 m (650 ft). Rainfall averages 3000–4000 mm (120–160 in) annually, mainly falling April–December. The annual average temperature is 25°C (77°F). DISTRIBUTION: Panama, Colón province on the Caribbean side of the dividing range, near the city of Colón, also in Comarca de San Blas territory; in only three small disjunct areas, one of which has been almost completely destroyed by a housing development.

Zamia dressleri is one of several species of the genus that have sunken veins on the surface of their leaflets. This corrugated condition is technically termed plicate. The closest relatives of *Z. dressleri,* both of which occur in Panama, are *Z. neurophyllidia* and *Z. skinneri.* For many years, plants of *Z. dressleri* were mistaken as being seedlings of *Z. skinneri,* but the leaflets of *Z. dressleri* are somewhat papery whereas those of *Z. skinneri* are thick and leathery. Mature plants can be distinguished because *Z. dressleri* usually has a single leaf with two to five pairs of leaflets, and a completely subterranean tuber, whereas *Z. skinneri* has three to six leaves to 2 m (6.6 ft) long and an arborescent stem as tall as 2.5 m (8.2 ft). There could be difficulty in distinguishing seedlings of *Z. skinneri* from plants of *Z. dressleri* if no collection data are at hand. To my knowledge, the two species do not overlap in their distribution even though their habitat preferences are similar. *Zamia dressleri* is found east of the Panama Canal, *Z. skinneri* some distance to the west of the canal.

In cultivation, *Zamia dressleri* may hold as many as five leaves if grown well. Cones are produced more frequently in cultivated plants, as opposed to the very rare sightings of cones in habitat. *Zamia dressleri* demands a warm, very humid environment and bright shade for best appearance and growth. Deprived of these requirements, specimens gradually decline and die. There are very few plants of *Z. dressleri* in cultivation, and I know of only one person who has successfully propagated this species by artificial pollination.

Zamia dressleri is known only from three disjunct populations, two in Colón, the other in Comarca de San Blas. One of the Colón populations has been all but eradicated by a housing development. The species is uncommon in its habitat, and individuals are scattered rather than forming colonies. Because of continued logging and land clearance, a great deal of this species' habitat is being lost. For these reasons, *Z. dressleri* must be considered critically endangered.

Zamia elegantissima Schutzman, Vovides & R. S. Adams 2000

The epithet for *Zamia elegantissima* is derived from *elegans,* Latin for elegant and meaning most elegant, referring to this cycad's appearance. Chromosome number $2n = 20$. **Stems** arborescent, to 3 m (9.8 ft) long, 10–15 cm (4–6 in) in diameter. **Leaves** as many as 40 in older specimens, upright and slightly arching, flat, bright glossy green, 1–2 m (3.3–6.6 ft) long, 35–40 cm (14–16 in) wide, emergent leaves light green, almost glabrous. Petiole terete, 43–44 cm (17 in) long, 8–10 mm (0.3–0.4 in) in diameter, nearly unarmed, prickles small and terete when present. Leaflets lanceolate, slightly falcate, 20–22 cm (8–8.7 in) long, 2.5–4 cm (1–1.6 in) wide, flat, apex short but not abruptly acuminate, the attachment 3–6 mm (to 0.2 in) wide, margins flat, toothed from the apex to approximately the midpoint of the leaflet, marginal teeth 0.5–1.5 mm long. **Female cones** solitary, erect, cylindrical, 20–30 cm (8–12 in) long, 6–10 cm (2.4–4 in) in diameter, finely tan to light brown tomentose. Peduncle short, the cone appearing sessile, finely tan tomentose. Sporophyll face about 1 cm (0.4 in) high and 2.4 cm (1 in) wide, terminal facet depressed, narrowly elliptic. Sarcotesta bright red. Sclerotesta ovoid, 28–30 mm (1.1–1.2 in) long, 16–18 mm (0.6–0.7 in) in diameter, smooth, with four to eight indistinct longitudinal grooves. **Male cones** solitary (?), erect, cylindrical, 20–30 cm (8–12 in) long, 3.7–4.5 cm (1.5–1.8 in) in diameter, finely beige-yellow to light brown tomentose. Peduncle 5.5–7.5 cm (2.2–3 in) long, 1.7–2.1 cm (0.7–0.8 in) in diameter, dark green, finely tomentose, the surface covered with irregular longitudinal grooves. Sporophylls 1.2–1.4 cm (0.5–0.6 in) long, with protruding hexagonal faces. Sporophyll face finely tan tomentose, 6–7 mm (0.2–0.3 in) high, 8–10 mm (0.3–0.4 in) wide, facets indistinct, terminal facet lacking in the upper half of the cone, small and sunken in lower half, a distinct horizontal ridge through the center. Sporangia in two patches on the edges of the sporophyll, with an open space 1–2 mm wide between them. **Habitat:** Lowland rainforest and secondary forest generally at elevations of 400–900 m (1300–3000 ft). **Distribution:** Panama, central part of the country on the Atlantic Coast in Colón province.

The botanist Robert L. Dressler first noted the cycad that was to become known as *Zamia elegantissima.* Dressler worked and lived in Panama for many years. During his fieldwork on orchids he became interested in the native cycads of Panama. At that time there was only one species of *Zamia* reported from Panama (Woodson 1943), *Z. skinneri.* Dressler's observations indicated that there were a number of very diverse, specifically distinct forms of *Zamia* in Panama. In an unpublished synopsis of the Panamanian zamias, Dressler proved that he had a better understanding of the Panamanian cycads than any of his contemporaries. His synopsis was ultimately given to Dennis W. Stevenson of the New York Botanical Garden who used it as a basis for his 1993 publication on the Zamiaceae in Panama. In Stevenson's publication the plant that was to become *Z. elegantissima* was misidentified as *Z. fairchildiana* from eastern Costa Rica and extreme western Panama. It was not until 2000 that Bart Schutzman, Andrew P. Vovides, and Russell S. Adams described and published *Z. elegantissima* as a new species.

Zamia elegantissima, as its name implies, is one of the most elegant of the arborescent zamias. Its tall stems, sometimes reaching 3 m (9.8 ft) in height, crowned by as many as 40 arching, glossy green leaves, combine to make *Z. elegantissima* one of the most desirable species of the genus. In cultivation, *Z. elegantissima* is robust, fast growing, and almost trouble-free. Specimens of coning size can be produced from seed in less than 10 years. I would not expect *Z. elegantissima* to be very cold hardy, but I have no information on this aspect of its cultivation. *Zamia elegantissima* will without doubt become one of the most sought-after species of the genus.

The conservation status of *Zamia elegantissima* is not adequately known. It has been reported to occur in scattered colonies over a fairly large area. Some populations are already known to have been eradicated as a result of clearing for agriculture. There are, however, numerous habitats that are still intact. With the continuing destruction of the rain forest throughout Panama, *Z. elegantissima* must be considered threatened.

Zamia encephalartoides D. W. Stevenson in Stevenson & Sabato 2001

PLATE 444–446

Zamia encephalartoides, the epithet referring to the female cones, which Dennis W. Stevenson considered similar to those of *Encephalartos,* is called *cacao del Indio,* alluding to the female cone's similarity to the fruit of *Theobroma cacao.* Chromosome number not known. **Stems** often reclining but with the apex erect, 1.5–2 m (4.9–6.6 ft) long, 20–25 cm (8–10 in) in diameter, in old age the stems often forked. Cataphylls triangular, about 5 cm (2 in) long and 2 cm (0.8 in) wide. **Leaves** usually 10–15, straight to slightly arching, 0.5–1 m (1.6–3.3 ft) long, moderately keeled. Petiole 15–25 cm (6–10 in) long and unarmed. Leaflets in 20–40 pairs, lanceolate, overlapping, median leaflets 20–30 cm (8–12 in) long, 1–3 cm (0.4–1.2 in) wide, margin entire and strongly revolute. **Female cones** solitary, ovoid to cylindrical, 25–40 cm (10–16 in) long, 10–15 cm (4–6 in) in diameter, tan tomentose, becoming green as the tomentum weathers away. Peduncle short. Sporophylls with well-defined facets. Sarcotesta yellow with a faint flush of light pink. Sclerotesta ovoid to triangular, 29–40 mm (1.1–1.6 in) long, 17–21 mm (0.7–0.8 in) in diameter, light brown, smooth. Chalaza not extended, measuring 5–8 mm (0.2–0.3 in) long, 4–5 mm (0.2 in) wide, containing one to four small pits. **Male cones** solitary, long cylindrical, 20–30 cm (8–12 in) long, 3–5 cm (1.2–2 in) in diameter, densely cream to tan tomentose. Peduncle erect, 5–8 cm (2–3.2 in) long. Sporophyll face of six steeply inclined facets surrounding a centrally depressed terminal facet. Sporangia covering the lower surface of the sporophyll and also present on the upper surface. **Habitat:** Steep canyons and ridges composed of loose, gravelly soil, in full sun, associated with cacti, other succulents, orchids, and *Tillandsia.* Rainfall is about 250 mm (10 in) annually, and the climate is extremely dry. **Distribution:** Colombia, thought to be restricted to the valley of the Río Magdalena.

The existence of the cycad that has been named *Zamia encephalartoides* has been known since about 1980. It was first referred to as the desert zamia because of the dry habitat in which it grows. Other remarkable features such as the lack of spines on the petiole and rachis, and the entire leaflet margins, set this species apart from other Colombian zamias. It is somewhat reminiscent of *Z. inermis* from Veracruz, Mexico, which also inhabits a dry habitat and has an unarmed petiole and entire leaflet margins. *Zamia encephalartoides* produces arborescent stems that can sometimes attain a length of almost 2 m (6.6 ft) though longer stems are generally decumbent.

The large female cones of *Zamia encephalartoides* produce seeds that have a yellow sarcotesta with a slight pinkish cast, unlike most other zamias whose sarcotestas are generally shades of orange or red. Bernard Fischer has reported that when the cones are receptive they attract hundreds of small reddish brown weevils, no doubt the pollinators. Fischer also commented that the resultant seed crop is generally a little more than 50% viable and ready to germinate when shed from the cone. He has also observed a butterfly that lays its eggs both on the cones and leaves of *Z. encephalartoides,* but noted that the larvae inflict only minimal damage.

Cultivation of *Zamia encephalartoides* is not well documented. Seed imports of this species have germinated reasonably well, but the resulting seedlings exhibit a very slow growth rate. To my knowledge there are no data relating to the cold hardiness of this *Zamia.* Bernard Fischer has observed that *Z. encephalartoides* will often rot off at the base when growing in shady, damp conditions in habitat. He further stated,

> Truckloads of plants were removed in the past, to be used as ornamentals in local gardens. I could not find a single live plant in the nearest town, so I can only conclude that plants taken from the wild are easily killed with overwatering. I am confident these plants will do well in cultivation provided they have good drainage, sun, and little water in winter in cooler climates.

The conservation status of *Zamia encephalartoides* seems to be reasonably secure. Apparently, the collecting of this *Zamia* for ornamental use has not continued, possibly because of the poor results experienced in transplanting them. The land is desertlike and not fit for growing crops or raising sheep or cattle. The only domestic animals able to survive in the area are goats.

Zamia fairchildiana L. D. Gómez 1982

PLATE 447

Zamia pseudomonticola L. D. Gómez 1982

Zamia fairchildiana is named in honor of David Grandison Fairchild (1869–1954), naturalist and plant explorer. Chromosome number not known. **Stems** to 1 m (3.3 ft) tall or more, 10–14 cm (4–5.5 in) in diameter, leaf bases not persistent and old plants gradually forming a cream-colored skinlike surface. Leaf cataphylls about 4 cm (1.6 in) long and 3 cm (1.2 in) wide, cone cataphylls about 7 cm (2.8 in) long and 3 cm (1.2 in) wide. **Leaves** numerous, 0.9–1.8 m (3–5.9 ft) long, 35–55 cm (14–22 in) wide. Petiole 35–45 cm (14–18 in) long, 7 mm (0.3 in) in diameter, slightly four-sided, glossy, persistently tomentose, moderately armed with spines 1–4 mm long. Leaflets in 10–30 pairs, oblong lanceolate, often falcate, glossy bright green, 20–30 cm (8–12 in) long, 3–5 cm (1.2–2 in) wide, gradually acuminate to a long, thin, drooping apex, margins usually entire but often with a few small teeth on both sides in the apical area. **Female cones** solitary, 19–22 cm (7.5–8.7 in) long, 7–8 cm (2.8–3.2 in) in diameter, densely gray tomentose. Peduncle 30–50 mm (1.2–2 in) long, 22–28 mm (0.9–1.1 in) in diameter, densely gray-brown tomentose. Sporophyll face 2–2.5 cm (0.8–1 in) high, 3–3.5 cm (1.2–1.4 in) wide, all facets more or less distinct, the terminal facet slightly sunken and darker than the lateral facets. Sarcotesta red when ripe. Sclerotesta irregularly ovoid and somewhat three-sided, 20–28 mm (0.8–1.1 in) long, 15 mm (0.6 in) in diameter, tan, smooth. **Male cones** usually one or two, rarely more, long conical, 40–50 cm (16–20 in) long, 2–4.5 cm (0.8–1.8 in) in diameter at the base, apex blunt, composed of gradually reduced sporophylls, leaf cataphylls about 7 cm (2.8 in) long and 2 cm (0.8 in) wide at the base, cone cataphylls about 12 cm (4.7 in) long and 2 cm (0.8 in) wide at the base. Peduncle erect, 5–7.5 cm (2–3 in) long, 14–18 mm (0.6–0.7 in) in diameter, densely gray tomentose. Median sporophylls 10–12 mm (0.4–0.5 in) long. Sporophyll face 5–10 mm (0.2–0.4 in) high and wide, slightly projecting, densely gray tomentose, with three distinct upper and lower facets, the terminal facet somewhat sunken and with a darker central area. Sporangia covering the entire lower surface and sides, and the forward half of the upper surface of the sporophyll. **Habitat:** Rocky limestone sites, usually near streams, in tropical rain forest from sea level to 1400 m (4600 ft). Rainfall averages 2000–2500 mm (79–98 in) annually, falling mainly in summer. The average annual temperature is 27°C (81°F). **Distribution:** Costa Rica, southeastern portion of the country, Puntarenas province, generally in the catchment of the Río Claro and Río Sierpe, extending into western Panama.

Luis Diego Gómez, a Costa Rican botanist, described *Zamia fairchildiana* in 1982. This cycad, until 1975, had been incorrectly referred to *Z. pseudoparasitica.* After the rediscovery of the real *Z. pseudoparasitica* in Panama, it was jokingly referred to as *Z. "pseudo-pseudoparasitica." Zamia fairchildiana* is definitely not an epiphyte like *Z. pseudoparasitica* but grows in dense rain forest on calcareous soils.

Gómez described *Zamia pseudomonticola* at the same time he published *Z. fairchildiana.* It was distinguished from *Z. fairchildiana* by its unarmed petiole and leaflets with a longer acuminate tip. I had two researchers try to find this cycad, with the help of Gómez, without success. All they were able to find at the type locality were specimens of typical *Z. fairchildiana.* Unless additional genuine specimens of *Z. pseudomonticola* are discovered in the future, that name should be considered a synonym of *Z. fairchildiana.*

The populations now accepted as *Zamia fairchildiana* are widely scattered through southeastern Costa Rica and western Panama. Considerable variation has been noted in shape and size of leaves, leaflets, and cones in some of these populations. A more through study may disclose the presence of more than one taxon within this complex.

Zamia fairchildiana is a handsome cycad, not difficult to grow when given a subtropical to tropical habitat or greenhouse conditions. During a few years in the 1980s, numbers of stems of this species were imported into the United States. For this reason it is not uncommon in collections. It is distressing that little has been done by way of artificial propagation to increase the number of this handsome species in cultivation. Because of increased interest in the conservation of endangered species, there have been some small quantities of viable seed produced by artificial means. If this trend continues, both botanical gardens and collectors may more easily obtain this cycad. *Zamia fairchildiana* is reasonably fast growing, and coning plants may be grown from seed in about 5–6 years. Unlike its wild siblings, which cone infrequently, this cycad in cultivation, given the necessary light, will cone annually after reaching maturity. The cones are easily pollinated and mature in about 9 months.

Although a great deal of the natural range of *Zamia fairchildiana* has been cleared, there are still considerable numbers of these cycads left in habitat. Regeneration in the wild, though infrequent, appears to be sufficient to maintain the populations. *Zamia fairchildiana* must be considered vulnerable.

Zamia fischeri Miquel 1847

PLATE 448

Zamia fischeri is named in honor of Friedrich Ernst Ludwig von Fischer (1782–1854), Russian botanist of German origin who was director of the St. Petersburg Botanical Garden, 1823–1850. Chromosome number $2n = 16$. **Stems** subterranean, tuberous, 10–30 cm (4–12 in) long, 3–4 cm (1.2–1.6 in) in diameter, generally with a single crown but old plants often becoming multiheaded. **Leaves** usually 3–5, rarely as many as 10, spreading, dark green, 33–66 cm (13–26 in) long, 10–16 cm (4–6.3 in) wide. Petiole terete, stipulate, 7.5–10 cm (3–4 in) long, 2–3 mm in diameter, unarmed. Leaflets in 10–23 pairs, flat, dark green, thin textured, glabrous, gradually and evenly acuminate, median leaflets 5–8 cm (2–3.2 in) long, 12–16 mm (0.5–0.6 in) wide, margin slightly revolute, with the apical two-thirds of the leaflet minutely serrate. **Female cones** solitary, erect, 5–12.5 cm (2–4.9 in) long, 4.5–5 cm (1.8–2 in) in diameter, at first gray to gray-brown tomentose, becoming glabrous and dark shiny green with age, apex blunt to narrow apiculate. Peduncle, 20–25 mm (0.8–1 in) long, 6–7 mm (0.2–0.3 in) in diameter, gray tomentose, the cone usually appearing sessile. Sporophyll face hexagonal, 10–13 mm (0.4–0.5 in) high, 18–25 mm (0.7–1 in) wide, gray tomentose, with seven more or less distinct facets, the terminal facet transversely concave. Sarcotesta pinkish red when seed first shed, orange when fully ripened. Sclerotesta subovoid, more or less three-sided, 13–15 mm (0.5–0.6 in) long, 10–12 mm (0.4–0.5 in) in diameter, light brown, smooth. **Male cones** one to three, erect until the pollen is shed, then leaning and soon dry, long conical, 7–11.5 cm (2.8–4.5 in) long, 20–23 mm (0.8–0.9 in) in diameter, densely gray tomentose. Peduncle gray tomentose, 13–20 mm (0.5–0.8 in) long, 7–8 mm (0.3 in) in diameter. Sporophylls wedge shaped, 5–7 mm (0.2–0.3 in) long. Sporophyll face hexagonal, 3 mm high, 5–7 mm (0.2–0.3 in) wide, more or less flat, the facets indistinct, the terminal facet slightly sunken. Sporangia in two patches on the edges of the lower side of the sporophyll. **Habitat:** Oak forest in areas of deep shade, at elevations of about 600 m (2000 ft). Rainfall averages 1500–2000 mm (59–79 in) annually, falling mainly in summer. Temperatures are 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Mexico, Tamaulipas state, west of Antiguo Morelos, also reported from near Ocampo.

When Friedrich Anton Wilhelm Miquel named *Zamia fischeri* in 1847, he based his description on young cultivated plants in the collection of the Belgian nurseryman, Louis Van Houtte. Van Houtte in turn had obtained his plants from Friedrich Ernst Ludwig von Fischer, director of the St. Petersburg Botanical Garden in Russia. For many years after its description, the native country of *Z. fischeri* was regarded as uncertain. The leading botanists of that time could not agree—Miquel suggested "In America calidiore," tropical America, while Alphonse de Candolle believed it came from South America. Eduard August von Regel, later director of the St. Petersburg Botanical Garden, attributed it without hesitation to Mexico, and of course he was correct.

For many years the name *Zamia fischeri* was misapplied to *Z. vazquezii,* a closely related species from the states of Hidalgo, San Luis Potosí, and Veracruz. That species differs from *Z. fischeri* in its fewer, longer, lighter green leaves, its larger, wedge-shaped, papery leaflets with more pronounced serrations, and its larger, persistently tomentose female cones. *Zamia vazquezii* has always been common in cultivation as opposed to the very small numbers of *Z. fischeri.* I would guess that more than 95% of the plants in cultivation labeled *Z. fischeri* are *Z. vazquezii.*

Zamia fischeri grows exceedingly well in cultivation. Coning frequency also increases in cultivation, and seed may be produced by anyone taking time to hand pollinate the cones. Seedlings grow rapidly, and a coning plant may be produced in about 4–5 years. As a houseplant, *Z. fischeri* is unexcelled. Its small size, lack of spines, flexible leaves, and adaptability to low light make it one of the best cycads for indoor culture. As a garden plant, *Z. fischeri* is one of the best, too. Its size, lack of spines, and flexible leaves allow it to be used near walks and other traffic areas, and as a border plant. If given sufficient moisture, *Z. fischeri* adapts to conditions of almost full sun to full shade. Even though the leaves of *Z. fischeri* are thin textured and appear very tropical and fernlike, they can withstand several degrees of frost without damage. The pests most frequently affecting *Z. fischeri* are scale insects and mealybugs. Periodic treatment is suggested, especially during spring and summer, to control such infestations. If these insects are allowed to go untreated, emergent leaves will die or be severely damaged, and in some cases the crown of the tuber may be killed.

The conservation status of *Zamia fischeri* is not good. Probably because of its small size and dark green leaves, *Z. fischeri* has been overcollected throughout most of its range. Habitat destruction has also contributed to its declining numbers. There are no areas where *Z. fischeri* can still be found in large numbers, and it remains only as scattered specimens. For these reasons, *Z. fischeri* must be considered endangered.

Zamia furfuracea Aiton 1789

PAGES 2–3, PLATES 5, 12, 449, 450

The epithet for *Zamia furfuracea* is derived from *furfuraceus,* Latin and meaning covered with branlike scales or powder, referring to the reddish brown scales on newly emergent leaves. Chromosome number $2n = 18$. **Stems** subterranean or short arborescent, tuberous, cylindrical, to 75 cm (30 in) long and 20 cm (8 in) in diameter, older specimens branching at the apex to form multiheaded plants as much as 1 m (3.3 ft) or more in diameter.

Leaves five to seven per crown, 0.5–2 m (1.6–6.6 ft) long, 11–25 cm (4.3–10 in) wide. Petiole 15–25 cm (6–10 in) long, 8–10 mm (0.3–0.4 in) in diameter, flattened above, rounded below, spiny, rarely unarmed. Leaflets in 10–15 pairs, thick and stiff, obovate oblong, 16–18 cm (6.3–7.1 in) long, 4–6 cm (1.6–2.4 in) wide, the upper margin convex, the lower more or less straight, obtuse or irregular at the apex, the apical third with numerous small blunt teeth. Mutant forms exist (Plate 12). **Female cones** solitary, erect, cylindrical, 16–24 cm (6.3–10 in) long, 6.5–7 cm (2.6–2.8 in) in diameter, densely reddish tomentose, the sterile apex mucronate, about 2 cm (0.8 in) long. Sporophylls in 10–12 vertical rows of 14–15 each. Sporophyll face 10–13 mm (0.4–0.5 in) high, 15–18 mm (0.6–0.7 in) wide, the terminal facet depressed. Peduncle 10–20 cm (4–8 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, densely tan tomentose. Sarcotesta red when ripe. Sclerotesta more or less three-sided, 11–15 mm (0.4–0.6 in) long, 8–10 mm (0.3–0.4 in) in diameter, light tan, smooth. Chalaza 1–2 mm in diameter, composed of two or three shallow pits. **Male cones** solitary, erect, cylindrical, 7–12 cm (2.8–4.7 in) long, 18–25 mm (0.7–1 in) in diameter, densely light brown tomentose. Peduncle 8–10 cm (3.2–4 in) long, 8–10 mm (0.3–0.4 in) in diameter, densely light brown tomentose. Sporophylls in 10–12 vertical rows of 18–20 each. Sporophyll face 2–3 mm high, 5–7 mm (0.2–0.3 in) wide. Sporangia in two patches on the lower edges of the sporophyll with a sterile central band 2–5 mm (to 0.2 in) wide. **Habitat:** Stabilized sand dunes under or near shrub cover, from the high-tide mark to about 25 m (82 ft). Rainfall averages more than 2000 mm (79 in) annually, falling mainly in summer. Temperatures are 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Mexico, Veracruz state, from south of Alvarado to just south of Playa de Montepio, also on some of the offshore islands.

Philip Miller first introduced *Zamia furfuracea* into England at Hampton Court in 1691. He had raised it from seeds sent by William Houston from “Old Vera Cruz, in America.” The species was described by Carl Linnaeus, the son, in William Aiton’s *Hortus Kewensis* in 1789. John Sims (1818) published a short description of *Z. furfuracea* and a hand-colored plate to illustrate it. These early beginnings were the start of a popularity that to the present could only be surpassed by *Cycas revoluta*. *Zamia furfuracea* is without a doubt the second most commonly grown cycad. It is also one of the most frequently used cycads in landscape plantings. The primary reasons for its popularity are its beauty, size, ease of horticulture, and availability. Hundreds of thousands of seeds of this cycad have been sent annually to many parts of the world. Its compact growth habit makes it usable even in small areas.

The habitat of *Zamia furfuracea* is restricted to the coastal sand dunes and offshore islands of southern Veracruz, Mexico. This cycad normally grows under the protection of the coastal scrub, but many plants can be found growing in full sun. Sun-grown plants are much more compact and present a better form than those grown under shaded conditions. *Zamia furfuracea* displays a high salt tolerance and can be observed growing in some areas just above the high-tide line. This makes it a very useful landscape plant for coastal areas. The soil in its habitat is almost pure sand except for a small amount of humus that the coastal scrub produces.

The growth rate of *Zamia furfuracea* is very rapid for a cycad, and coning plants can be produced from seed in about 3 years. Although *Z. furfuracea* grows in pure sand in its natural habitat, it adapts well to almost any soil type. In some areas such as Florida, the accidental importation of its insect pollinators has proceeded to make viable seed the rule rather than the exception in landscape plantings. This *Zamia* is also very adaptable to various climatic conditions and has shown dependable growth and hardiness even in Mediterranean climates. Cold hardiness is good to several degrees of frost, with only occasional foliage burn or defoliation occurring during hard freezes. In southern California this occurs at about −3°C (27°F). Keeping the stem completely subterranean will help protect it from cold damage.

Until more recent times, tens of thousands of *Zamia furfuracea* plants were removed from habitat for use as ornamentals, mainly in the United States. Through enforcement of conservation laws protecting these plants by the Mexican government, this international trade has been stopped. Even though the range of *Z. furfuracea* has been reduced over a large part of its original occurrence through overcollecting, its status still appears secure. Plants in the wild are not uncommon, and regeneration is prolific. The habitat of *Z. furfuracea* is sand hills, not fit for the production of crops, though the area is used to raise cattle. Thus no major further habitat destruction is foreseen. *Zamia furfuracea* must be considered threatened because of its reduced habitat and the overall reduction of its numbers in the wild.

Zamia gentryi Dodson 1998

Zamia gentryi is named in honor of Alwyn Howard Gentry (1945–1993), who participated in the collection of the type specimen and who was a friend of Calaway H. Dodson. Chromosome number not known. **Stems** to 1 m (3.3 ft) long or more and 12 cm (4.7 in) in diameter, decumbent if growing in the ground or U shaped if growing as an epiphyte. Cataphylls fleshy, elongate triangular, to 12 cm (4.7 in) long, those preceding cone formation with a long, twisted, acuminate apex. **Leaves** usually 5–9, sometimes as many as 13, stiffly erect or arching, to 2.5 m (8.2 ft) long, 60–80 cm (24–32 in) wide, emerging leaves bright reddish green, turning pale yellow-green at maturity. Petiole 45–90 cm (18–36 in) long and armed with numerous stout spines to 1 cm (0.4 in) long. Leaflets opposite to subopposite, lanceolate, somewhat oblique, slightly falcate, light yellow-green above and below, to 40 cm (16 in) long, 3.5–6 cm (1.4–2.4 in) wide, apex acute, the longitudinal veins sunken, giving the leaf a corrugated appearance, margin entire, often slightly revolute. **Female cones** solitary, barrel shaped to cylindrical, to 30 cm (12 in) long and 15 cm (6 in) in diameter, densely red-brown tomentose. Sporophylls in 7–10 vertical rows of 12–30 each. Sporophyll face hexagonal, densely covered with red-brown tomentum, the facets distinct, the terminal facet slightly sunken. Sarcotesta slightly three-sided, pink to red when ripened. Sclerotesta cylindrical, about 35 mm (1.4 in) long and 17 mm (0.7 in) in diameter, light brown, smooth. **Male cones** usually one to seven, erect, about 35 cm (14 in) long and 3.8 cm (1.5 in) in diameter, densely wine red tomentose. Peduncle decumbent, flattened cylindrical, to 20 cm (8 in) long, 12–15 mm (0.5–0.6 in) in diameter. Sporophyll face hexagonal, dome shaped, densely wine red tomentose. **Habitat:** Dense shade under primary rain forest at elevations of 300–1800 m (980–5900 ft), on, not in, extremely compact and nonabsorbent kaolin soil, the roots spreading under a thin layer of leaf mold. Rainfall averages about 6500 mm (260 in) annually, falling throughout the year, and the habitat is extremely wet. **Distribution:** Ecuador, Pacific slope of the northwestern part of the country, Carchi and Esmeraldas provinces, near Alto Tambo and between Lita and San Lorenzo, also thought to occur in adjoining Colombia.

Zamia gentryi, described in 1998, has been known since 1988 when it was first collected by Harry Luther of the Marie Selby Botanical Gardens, Sarasota, Florida. The closest relative of *Z. gentryi* is without doubt *Z. roezlii,* which it closely resembles. These two species may be distinguished using the following differences. The stem of *Z. gentryi* seldom exceeds 1 m (3.3 ft) in length and 12 cm (4.7 in) in diameter and is usually decumbent whereas the stem of *Z. roezlii* may reach 6.5 m (21 ft) in length and 30 cm (12 in) in diameter and is generally erect in specimens to 3 m (10 ft) tall, decumbent in larger plants. Mature *Z. gentryi* holds 5–13 leaves whereas *Z. roezlii* holds 15–45. Leaves of the two species are very similar and often difficult to tell apart, but the leaflets of *Z. gentryi* are yellowish green above and below whereas those of *Z. roezlii* are dark green above, lighter green below. The leaflets of both species have sunken veins, giving a corrugated look to the upper surface, but the veins are much more prominently sunken in *Z. roezlii* than in *Z. gentryi.* Female cones of *Z. gentryi* are barrel shaped to cylindrical and as long as 30 cm (12 in) whereas those of *Z. roezlii* are cylindrical and have been recorded as long as 90 cm (35 in). The sarcotesta color of *Z. gentryi* ranges from pink to red whereas that of *Z. roezlii* is orange-red.

Zamia gentryi occurs as a mid- to high-elevation plant whereas *Z. roezlii* is generally restricted to areas of low-elevation coastal swamp. Calaway H. Dodson has reported that the two species grow together in Esmeraldas, Ecuador, at elevations of 300–400 m (980–1300 ft) on the road between Lita and San Lorenzo. In spite of the fact that the two species cone at the same time, generally December, there has been no evidence of hybridization. An explanation might be that insect pollinators are species specific.

Zamia gentryi can be somewhat difficult in cultivation as it requires almost continual warm temperatures and high humidity. It can, however, be successfully grown in tropical climates or in greenhouses that maintain the proper conditions. Although *Z. gentryi* grows in dense shade in its habitat, in cultivation it has grown well under conditions of partial sunlight. Cultivated plants cone more frequently than those in the wild, possibly because of brighter light in cultivation.

The conservation status of *Zamia gentryi* seems relatively secure. Dodson reported a population density of about 24 plants per hectare (2.5 acres), and given the large area of distribution, that would indicate a sizable total population. For these reasons, *Z. gentryi* is not considered threatened.

Zamia herrerae Calderón & Standley 1924

PLATE 451

Zamia herrerae is named in honor of Héctor Herrera, a scientist from El Salvador. **Stems** subterranean, tuberous, to 20 cm (8 in) long, 5–10 cm (2–3.9 in) in diameter. **Leaves** usually one to five, dark green, erect, 40–60 cm (16–24 in) long, slightly keeled. Petiole 10–20 cm (4–8 in) long, moderately armed with spines 1–2 mm long, with similar spines along the rachis. Leaflets in 20–30 pairs, linear lanceolate, 15–22 cm (6–8.7 in) long, 8–13 mm (0.3–0.5 in) wide, 17- to 21-nerved, thick, lustrous dark green, lighter below than above, gradually acuminate from the lower third toward the leaflet apex, margin revolute, bearing a few small spine-tipped teeth about 2 cm (0.8 in) apart, the lower third of the leaflet entire. FEMALE CONES solitary, cylindrical to ovoid, 12.6–15 cm (5–6 in) long, 6–7.5 cm (2.4–3 in) in diameter. Peduncle about 60–78 mm (2.4–3.1 in) long, 15 mm (0.6 in) in diameter. Sporophylls 25–28 mm (1–1.1 in) long. Sporophyll face hexagonal, 15–17 mm (0.6–0.7 in) high, 27–30 mm (1.1–1.2 in) wide, moderately tomentose, the terminal facet large and sunken, medial facets not distinct but merging into a raised border around the terminal facet. Sarcotesta orange-red to red when ripe. Sclerotesta ovoid, more or less three-sided, 19–21 mm (0.7–0.8 in) long, 11–14 mm (0.4–0.6 in) in diameter, light tan, smooth. MALE CONES solitary, rarely two, cylindrical, 4–7 cm (1.6–2.8 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, tomentose, light brown. HABITAT: Understory of rain forest. DISTRIBUTION: El Salvador, vicinity of Sonsonate and San Salvador, and not known for sure from any other location.

Zamia herrerae was named by Paul C. Standley in 1924 from specimens collected by Salvador Calderón in the vicinity of Sonsonate, El Salvador, in 1923. Calderón and Standley named it in honor of Héctor Herrera of Sonsonate, Standley's host during several expeditions in the area.

Zamia herrerae is not commonly grown because of the difficulty of acquiring specimens rather than any problems in their cultivation. It is not a particularly handsome plant with its few leaves and rather narrow leaflets, and this may also have some bearing on its scarcity. I am aware of a number of plants in Florida that grow and cone without any special care. Viable seed has been produced on these plants, so the number in cultivation is slowly increasing.

There is insufficient information on the conservation status of *Zamia herrerae.* It must be expected to be suffering the same pressures of habitat loss through agriculture and urbanization as the other Central American zamias and thus should be considered threatened until more complete information is available.

Zamia hymenophyllidia D. W. Stevenson in Stevenson & Sabato 2001

The epithet for *Zamia hymenophyllidia* is derived from *hymen-*, Greek for thin or membranous, and *phyllon*, leaf, referring to the thin texture of the leaflets. Chromosome number not known. STEMS subterranean, tuberous, 2–4 cm (0.8–1.6 in) in diameter. Cataphylls long triangular, papery, 20–30 mm (0.8–1.2 in) long, 5–10 mm (0.2–0.4 in) wide at the base. LEAVES generally two to five, erect, oblong, 30–70 cm (12–28 in) long. Petiole terete, to 35 cm (14 in) long, moderately armed with very small prickles. Rachis terete, 20–35 cm (8–14 in) long, usually unarmed. Leaflets in 4–10 pairs, elliptical to elliptical lanceolate, apex long acuminate, median leaflets 12–15 cm (4.7–6 in) long, 1–2 cm (0.4–0.8 in) wide, margin entire or rarely with a few very small apical teeth. FEMALE CONES solitary, leaning to pendent, cylindrical to ovoid cylindrical, about 5 cm (2 in) long, 3–4 cm (1.2–1.6 in) in diameter, dark red-brown tomentose. Peduncle about 15 cm (6 in) long and 5 mm (0.2 in) in diameter. Sarcotesta red to orange-red. Sclerotesta 10–12 mm (0.4–0.5 in) long, 5–8 mm (0.2–0.3 in) in diameter. MALE CONES several, ovoid, 1–3 cm (0.4–1.2 in) long, 3–5 mm (to 0.2 in) in diameter, brown tomentose. Peduncle 10–30 cm (4–12 in) long. Sporangia in a patch on the underside of the sporophyll but often with one to three sporangia on the upper surface. HABITAT: Lowland primary rain forest. DISTRIBUTION: Colombia, southeastern Amazonian part of the country in Amazonas department.

Zamia hymenophyllidia is a relatively newly described, cycad from Colombia about which little is known. It grows as an understory plant in primary rain forest. Only three small colonies have been discovered. Its closest relative appears to be *Z. melanorrhachis*, which is also found in Amazonian Colombia. *Zamia hymenophyllidia* differs from *Z. melanorrhachis* in that it has broad, thin leaflets and does not exhibit the purplish to black petiole and rachis of *Z. melanorrhachis*. The leaflets of *Z. melanorrhachis* are lanceolate and have well-developed marginal teeth in the apical two-thirds whereas those of *Z. hymenophyllidia* are broadly elliptical and have entire margins, or if serrate, the teeth are inconspicuous and restricted to the leaflet apex. The unique feature that relates these two species is the extreme length, and thinness, of the peduncles of the male cones.

Nothing is known regarding the cultivation of *Zamia hymenophyllidia*. Its habitat indicates that it would probably grow well in tropical climates that have the needed high humidity. Greenhouse culture might also be successful if high humidity were maintained.

The conservation status of *Zamia hymenophyllidia* is not known. The three small populations have been reported to produce seeds and seedlings. The species may be found to have a larger distributional range when additional fieldwork is carried out, but based on the knowledge at hand, *Z. hymenophyllidia* must be considered endangered.

Zamia inermis Vovides, J. D. Rees & Vázquez-Torres 1983

PLATES 452–455

Zamia inermis, the epithet Latin for unarmed, referring to the spineless petiole, rachis, and leaflet margins, is called *palmita.* Chromosome number $2n = 16$. STEMS to 1 m (3.3 ft) long, longer stems usually decumbent or pendent from cliff sides, 12.5–20 cm (5–8 in) in diameter, older plants often dichotomously branched at their apex, leaf bases not persistent, leaving a more or less smooth or sometimes cracked and barklike epidermis on the exposed portions of the stem. LEAVES 10–20 or more, 0.5–1.3 m (1.6–4.3 ft) long, 45–60 cm (18–24 in) wide, upright and forming a dense crown. Petiole and rachis more or less round, unarmed, with the expanded base tomentose. Leaflets in 25–35 pairs, glossy bright green, lighter below than above, smooth, 22–28 cm (8.7–11 in) long, 9–11 mm (0.4 in) wide, stiff, linear lanceolate, margin entire and slightly revolute. FEMALE CONES usually one or two, rarely more, cylindrical, 13–19 cm (5.1–7.5 in) long, 8.5–9.5 cm (3.3–3.7 in) in diameter, densely light tan tomentose, reported to produce seed at any time of the year though my plants in cultivation generally producing cones in October that are pollinated in December, shedding their seed 12–14 months from the time of fertilization. Peduncle 4–5 cm (1.6–2 in) long, 2.5 cm (1 in) in diameter. Sporophylls 25–28 mm (1–1.1 in) long. Sporophyll face 18–28 mm (0.7–1.1 in) high, 30–42 mm (1.2–1.7 in) wide, with six distinct lateral facets and a terminal facet. Sarcotesta pinkish red when seed is first shed, bright orange when ripe, the areas exposed to sunlight between the sporophylls turning dark green. Sclerotesta irregularly ovoid, somewhat three-sided, 17–27 mm (0.7–1.1 in) long, 15–20 mm (0.6–0.8 in) in diameter, light tan, smooth. MALE CONES usually one to three, sometimes more, resembling a small ear of maize or corn, 9–17 cm (3.5–6.7 in) long, 2.5–3.5 cm (1–1.4 in) in diameter, light tan tomentose. Peduncle 35–65 mm (1.4–2.6 in) long, 10–12 mm (0.4–0.5 in) in diameter, densely light tan tomentose. Sporophylls 9–12 mm (0.4–0.5 in) long. Sporophyll face unequally hexagonal, about 4 mm high, 6–8 mm (0.2–0.3 in) wide, the facets distinct, the terminal facet flat. Sporangia in two patches separated by a sterile zone about 4 mm wide and confined to the lower surface of the sporophyll. HABITAT: Small colonies in the coastal "selva baja caducifolia" (Rzedowski 1978), low-elevation deciduous forest, 150–300 m (490–1000 ft). These coastal hills are quite dry and *Zamia inermis* grows among volcanic rocks in poor soil containing very little organic material. It appears that in most cases the cycads grew under sparse tree cover but because of extensive clearing of the area for cattle grazing, the remaining plants are restricted to cliffs and other rocky, undisturbed areas. DISTRIBUTION: Mexico, central Veracruz state, Actopan district.

Zamia inermis is one of the more dramatic cycad discoveries made in Mexico. It seems strange that a cycad as distinctive as this species could have remained unknown for so many years, stranger still when one considers that its habitat is close to a major city. The explanation, no doubt, is its very limited range. Since the mid-twentieth century, the range of *Z. inermis* has been drastically reduced through the clearing of natural vegetation to make way for cattle grazing. The remaining zamias are found only on rocky outcrops that protect them from cattle and from being overwhelmed by the tall grass planted as cattle feed.

When *Zamia inermis* was discovered, it was thought that it might possibly be the rediscovery of *Z. monticola* (= *Z. muricata*), described by Charles J. Chamberlain from the same general area. It was soon obvious that this singularly beautiful cycad is quite distinct. When I first studied cultivated plants of *Z. inermis,* I was impressed by the general resemblance of its leaves to those of *Microcycas.* It has the same chopped-off look at the apex of the leaf that is caused by the apical leaflets being almost as long as the median ones. It is also arborescent, a feature it shares with only two other Mexican zamias, *Z. furfuracea* and *Z. soconuscensis.* Its treelike nature along with its striking glossy green leaves, and complete lack of spines or teeth, make it easy to identify.

Specimens of *Zamia inermis* that I have in cultivation have grown rapidly and do not demand special treatment. Not surprisingly, they have larger tubers and longer, broader leaves than wild plants. The male cones produce a large quantity of pollen that is shed over 1–2 weeks. Usually, two or more male cones are produced at each stem apex, and these ripen in sequence, prolonging the shedding of pollen. When the female cones are receptive, cracks open around their apex and base. These openings are also often connected by vertical cracks, making pollination more easily accomplished. I have hand pollinated a number of cones and the seed has proved to be 85–95% viable. The seedling leaves hold four leaflets each, and the leaflets exhibit three to seven teeth on each margin. These marginal teeth are lost as the plant matures.

The range of *Zamia inermis* is well to the north of that of *Z. furfuracea,* and this would lead one to believe that it will be as hardy in cultivation. Without doubt, *Z. inermis* would become a very popular landscape plant if it were available in sufficient numbers. There is no reason why it could not be artificially propagated in numbers large enough to secure its place in horticulture.

Zamia inermis must be considered extremely endangered. The primary problem has been the drastic reduction of its habitat. The secondary problem is not so easily explained. Virtually no regeneration in habitat is taking place, and female cones produce very few, if any, viable seeds. One explanation that has been suggested (Andrew P. Vovides, pers. comm.) is that aerial spraying of crops in surrounding areas may have depleted the number of insect pollinators to a dangerously low level. Whatever the problem, this beautiful species should receive complete protection in the wild and the necessary attention in cultivation to promote propagation and ensure its continued existence.

Zamia integrifolia Aiton 1789

PLATES 456, 457

Zamia floridana A. de Candolle 1868
Zamia umbrosa Small 1921
Zamia silvicola Small 1926

Zamia integrifolia, the epithet derived from *integer,* Latin for entire, and *folium,* leaf, referring to the entire leaflet margin, is called Florida arrowroot, Indian bread root, *coonti, coontie, koonti, conti,* and by Seminole Indians, *conti-hateka.* Chromosome number $2n = 16$. **Stems** subterranean, tuberous, 20–25 cm (8–10 in) long, 6–8 cm (2.4–3.2 in) in diameter, younger plants with a single crown, old specimens becoming multiheaded. **Leaves** usually three to five, erect to spreading, glossy, medium to dark green, 46–91 cm (18–36 in) long, 12–15 cm (4.7–6 in) wide, slightly to moderately keeled. Petiole round, 22–30 cm (8.7–12 in) long, 5–6 mm (0.2 in) in diameter, unarmed. Leaflets in 10–25 pairs, glabrous, flexible, upper ones flat, lower ones overlapping, basal and apical leaflets slightly reduced in length, median leaflets straight, 8.5–12 cm (3.3–4.7 in) long, 8–10 mm (0.3–0.4 in) wide, apex blunt, margin strongly revolute, entire except for a few minute teeth at the apex. **Female cones** solitary, cylindrical, 12–15 cm (4.7–6 in) long, 5–6 cm (2–2.4 in) in diameter, dark brownish red tomentose, apex blunt. Peduncle 5–10 cm (2–3.9 in) long, 12–17 mm (0.5–0.7 in) in diameter. Sporophyll face hexagonal, 1.5–2 cm (0.6–0.8 in) high, 2.5–3 cm (1–1.2 in) wide, the terminal facet more or less flat. Sarcotesta orange to red when ripe. Sclerotesta ovoid to globose, 17–21 mm (0.7–0.8 in) long, 10–14 mm (0.4–0.6 in) in diameter, tan, smooth. **Male cones** usually one to four, erect, cylindrical to conical, 6–10 cm (2.4–3.9 in) long, 2.5–3 cm (1–1.2 in) in diameter, densely reddish brown tomentose, apex with a short blunt apiculum. Peduncle 4–8 cm (1.6–3.2 in) long, 8–10 mm (0.3–0.4 in) in diameter, round in cross section, moderately reddish brown tomentose. Sporophylls wedge shaped, 10–11 mm (0.4 in) long. Sporophyll face hexagonal, the facets slightly obscure, 3–5 mm (to 0.2 in) high, 5–8 mm (0.2–0.3 in) wide, projecting 2 mm, reddish brown tomentose. Sporangia in a single patch with a large notch at the outside edge. **Habitat:** Dry pinelands or dry oak woods, usually in sand or marl (coral rock), also in hammocks, from sea level to about 100 m (330 ft). On the Gulf Coast it is often associated with shell deposits left by early Indian inhabitants. **Distribution:** United States, extreme southeastern Georgia, southward through peninsular Florida, including the Florida Keys.

On February 2, 1767, Dr. Alexander Garden, in honor of whom the genus *Gardenia* was named, of Charleston, South Carolina, wrote in a letter to John Ellis of London, England,

> The doctor carries home some packages of East Florida plants which you will see. I shall be very glad to know what you make of John Bartram's Tallow tree, and what you call that herb whose leaves look like the Fern Osmund Royal, while its seeds are large red berries in a cone, somewhat resembling the Magnolia in appearance.

Garden's plants are said to have reached the garden of the princess of Wales in 1768. There they came to the attention of William Aiton, the superintendent. Aiton was a Scot who had been hired by Alexandra, princess of Wales, to establish a botanical garden at Kew, her residence. It was from this beginning that the Royal Botanic Gardens, Kew, emerged as a scientific institution. From Garden's specimens, Carl Linnaeus, the son, described *Zamia integrifolia* in Aiton's *Hortus Kewensis* in 1789.

The taxonomy of the Florida zamias is still not acceptable to all researchers of the genus, and there continue to be many unanswered questions. At present, *Zamia integrifolia* is the only name used for all zamias found in Florida and Georgia. In the past, *Z. angustifolia* (actually a Bahamian species), *Z. floridana, Z. silvicola,* and *Z. umbrosa* had all been described from or attributed to Florida. Not only are the Florida zamias assigned to *Z. integrifolia* but most of those from the West Indies as well. The West Indian populations differ more dramatically in their morphology and need more detailed study. Needless to say, there is still work to be done in the *Z. integrifolia* complex.

The various forms of *Zamia integrifolia* found in Florida, though growing in differing habitats, have genetic differences that cannot be accounted for by the effects of their surroundings. An experiment carried out by Daniel B. Ward (1978) of the University of Florida proves this point. Plants from five populations were maintained in cultivation under identical conditions of soil and light for 10 years, and they retained their differences in leaf shape and leaflet width.

Zamia integrifolia grows well in cultivation and is generally trouble-free. Larvae of the *Zamia* butterfly (*Eumaeus atala*) can attack it (Plate 21). *Zamia integrifolia* does best in subtropical to tropical climates but can grow equally well in temperate climates. It must always be planted with the tuber slightly below ground level to protect it in times of freezing weather. Even if its leaves are killed by frost, it will send up a new flush as soon as the weather warms. The small size of *Z. integrifolia* makes it a fine border plant or for use in any cramped garden space. Multiheaded specimens are good subjects for bonsai and in other types of planters.

The conservation status of *Zamia integrifolia* is not good. The decline of the Florida zamias started in the nineteenth century when massive numbers of *Z. integrifolia* were removed from their habitat to be processed into Florida arrowroot, a flourlike starch product used in making bread and crackers. During the peak production years, 9100–14,000 kg (10–15 tons) of plants (Moya et al. 1957) were processed each day! The last factory closed in 1925 after the *Zamia* populations became too small to support it. In contemporary times, habitat destruction for agriculture and housing development has dealt a devastating blow to the continued existence of Florida zamias. More recently, Florida zamias have reached new heights of popularity as garden and landscape plants. In a highway project, several thousand plants were used in plantings along a major freeway. This growing popularity has caused more interest in artificial propagation, and many thousands of these zamias are now grown from seed.

Zamia ipetiensis D. W. Stevenson 1993

PLATES 458, 459

The epithet for *Zamia ipetiensis* refers to the Ipeti Indians, who inhabit the area where this cycad is native, or the nearby town of Colono Ipeti, Panama, or possibly both. Chromosome number $2n = 23$. **Stems** subterranean, subglobose, to 10 cm (4 in) in diameter. Cataphylls ovate, 3–4 cm (1.2–1.6 in) long, 4–5 cm (1.6–2 in) wide. **Leaves** usually solitary, rarely as many as two or three, medium green, 0.5–1.5 m (1.6–4.9 ft) long, 40–43.8 cm (16–17 in) wide. Petiole 40–56 cm (16–22 in) long, 7–10 mm (0.3–0.4 in) in diameter, sparsely to densely armed with prickles. Leaflets in 3–12 pairs, narrowly to broadly oblanceolate, narrowed at the base, apex abruptly and unequally acuminate, median leaflets 20–40 cm (8–16 in) long, 5–8 cm (2–3.2 in) wide, margins slightly revolute, entire except for some fine serrations on both sides near the leaflet apex. **Female cones** solitary, erect, cylindrical to ovoid cylindrical, 15–20 cm (6–8 in) long, 5–7 cm (2–2.8 in) in diameter, wine red to dark red-brown tomentose. Peduncle 2.5–5 cm (1–2 in) long, 1 cm (0.4 in) in diameter, densely tomentose. Sporophyll face hexagonal, about 1 cm (0.4 in) high and 1.5 cm (0.6 in) wide. Sarcotesta pink to light red when ripe. Sclerotesta long ovoid, 15–20 mm (0.6–0.8 in) long, 5–8 mm (0.2–0.3 in) in diameter, smooth. **Male cones** solitary (?), erect, cylindrical to ovoid cylindrical, 4–6 cm (1.6–2.4 in) long, 1–1.5 cm (0.4–0.6 in) in diameter, densely cream to tan tomentose. Peduncle 2–4 cm (0.8–1.6 in) long. Sporophyll face 4–5 mm (0.2 in) in diameter, with six steeply inclined facets surrounding a centrally depressed terminal facet. Sporangia spread evenly across the lower surface of the sporophyll and extending up the sides, ending on either side of the upper surface. **Habitat:** Primary and secondary rain forest at elevations of 100–500 m (330–1600 ft). Rainfall averages 2000 mm (79 in) annually, falling mainly in summer. The average annual temperature is 25°C (77°F). In more recent years a great deal of the forest has been removed but the zamias are surviving in cleared areas. **Distribution:** Panama, Panama province, a relatively small area near the village of Colono Ipeti.

Zamia ipetiensis is one of the more recent discoveries in the genus. Originally found by Robert L. Dressler, an orchid specialist who spent many years in Panama, and described by Dennis W. Stevenson in 1993, its closest relative appears to be *Z. cunaria,* with which it has similarities in stem, leaf, and leaflets. Stevenson's descriptions of the two taxa are identical except for a minor difference in the shape of the leaflets. *Zamia* leaflets are very plastic in form and often appear different on plants grown in sun versus those grown in the shade. Plants I have seen in cultivation display a distinct difference in the leaflet apex with *Z. ipetiensis* displaying a gradually acuminate apex, *Z. cunaria* a more or less abruptly acuminate apex. The female cones of *Z. ipetiensis* have a distinctly lighter colored terminal facet whereas those of *Z. cunaria* have an overall reddish brown coloration. I believe it would be difficult, if not impossible, to identify the two species based on leaf morphology alone.

Zamia ipetiensis has not shown any problems in cultivation. It requires a tropical climate and well-drained soil with abundant organic material. Tropical greenhouse conditions seem sufficient for good growth and coning. Because this species normally only produces one or two leaves at a time, it will probably never be in demand as a landscape plant. The overall growth habit and size and shape of leaves and leaflets are not distinctive enough to assure it much popularity with collectors.

The habitat of *Zamia ipetiensis* has suffered considerable damage through development of the land for farming. This cycad, however, is still quite common within its range, and it should not be considered threatened.

Zamia jirijirimensis R. E. Schultes 1953

Zamia jirijirimensis, the epithet referring to the waterfall and rapids at Jirijirimo, Colombia, where this cycad was discovered, is called *gaw* by Taiwano Indians. Chromosome number not known. STEMS subterranean, ovoid, to 14 cm (5.5 in) long and 7 cm (2.8 in) in diameter. Cataphylls long triangular, fibrous, brown, about 4 cm (1.6 in) long and 2 cm (0.8 in) wide. LEAVES usually four or five, erect, shiny dark green, moderately lighter below than above, 47–65 cm (18–26 in) long, 40–54 cm (16–21 in) wide. Petiole to 25 cm (10 in) long and 8 mm (0.3 in) in diameter, unarmed or lightly armed. Leaflets narrowly lanceolate, stiff, 20–27 cm (8–11 in) long, 15–22 mm (0.6–0.9 in) wide, margin strongly revolute, entire. FEMALE CONES solitary, cylindrical, 7–9 cm (2.8–3.5 in) long, 4–4.5 cm (1.6–1.8 in) in diameter, the surface golden tomentose. Peduncle robust, erect, about 10 cm (4 in) long, round in cross section, golden tomentose. Sarcotesta bright orange. Sclerotesta subovoid, somewhat three-sided, about 14 mm (0.6 in) long and 8 mm (0.3 in) in diameter. MALE CONES usually one or two (or more?), cylindrical, about 3.5 cm (1.4 in) long and 1 cm (0.4 in) in diameter, deep yellow tomentose. HABITAT: Mainly in sunny situations in an extensive white sand savanna. DISTRIBUTION: Colombia, Amazonas department, along the Río Apaporis, Raudal de Jirijirimo.

Not much is known about *Zamia jirijirimensis* other than the collection data published by Richard Evans Schultes. *Zamia jirijirimensis* was said by Schultes to be abundant at the type locality and used by the Karapana, Kayaburi, and Taiwano Indians, who often gather the tubers and prepare a starchy meal or farina from them. This is used as food on long trips.

Because of its remote habitat, the probability that *Zamia jirijirimensis* will be brought into cultivation is low. I know of no plants in cultivation, thus there is no information available on its horticultural requirements. It would be a major botanical achievement to introduce this species into cultivation so that it could be properly studied and evaluated. We have no reason to believe that it should require any special treatment other than protection from cold and the usual well-drained soil.

The conservation status of *Zamia jirijirimensis* is not known. At the time it was discovered, in 1951, it was common in its habitat even though it was used by the local Indians as an item of food. The habitat is still remote and not often visited by outsiders, and this could afford it considerable protection.

Zamia kickxii Miquel 1844a

PLATE 460

Zamia kickxii is named in honor of Jean Jacques Kickx (1842–1887), Belgian botanist. Chromosome number not known. STEMS subterranean, tuberlike, 12.5–15 cm (5–6 in) long, 25–38 mm (1–1.5 in) in diameter, younger plants with a single crown, older plants commonly dividing at the apex to form multiple crowns, the old leaf bases and cataphylls soon shed to form a smooth skin. Cataphylls long triangular, stipulate, lightly tomentose. LEAVES usually two or three, glabrous, medium green, 37.5–60 cm (15–24 in) long, 10–15 cm (4–6 in) wide, flat. Petiole brownish green, 10–15 cm (4–6 in) long, 3–4 mm in diameter, unarmed. Leaflets in 15–18 pairs, lanceolate elliptical, 5–9 cm (2–3.5 in) long, 1.5–2 cm (0.6–0.8 in) wide, margin flat or slightly revolute, entire except for the apical quarter, which has numerous small, closely set serrations. FEMALE CONES solitary, rarely two, 7–10 cm (2.8–4 in) long, 4.5–5 cm (1.8–2 in) in diameter, greenish brown, apex with a blunt sterile cap often ending in a narrow spinelike appendage, the terminal facet darkened by blackish brown tomentum. Peduncle 30–50 mm (1.2–2 in) long, 10–12 mm (0.4–0.5 in) in diameter, densely tomentose. Sporophyll face rhomboid, 12–15 mm (0.5–0.6 in) high, 18–22 mm (0.7–0.9 in) wide, the terminal facet distinct, lateral facets somewhat indistinct. Sarcotesta red-orange when ripe. Sclerotesta globular to ovoid, somewhat three-sided, 12–15 mm (0.5–0.6 in) long, 10–11 mm (0.4 in) in diameter, tan, smooth. MALE CONES one to several, erect until the pollen is shed, 4–6 cm (1.6–

2.4 in) long, 15–18 mm (0.6–0.7 in) in diameter, gray-green with an overlay of red-brown tomentum, especially at the terminal facets, apex of reduced sporophylls. Peduncle 2.5–3 cm (1–1.2 in) long, 5–7 mm (0.2–0.3 in) in diameter. Sporophylls lightly red-brown tomentose. Sporophyll face 2 mm high, 3–4 mm wide, the facets indistinct. Sporangia in a single patch. HABITAT: Dry subtropical grassland and thorny scrubland. Rain falls all year but mainly March–October. Temperatures range from a maximum of 25°C (77°F) to a minimum of 13°C (55°F). DISTRIBUTION: Cuba, Pinar del Río province in the western part of the island.

In the past, several taxonomists placed *Zamia kickxii* in synonymy under *Z. pygmaea.* This is not surprising as the two species are quite similar in some respects. There are differences, however, in cone color and size, and the larger size of leaves and tubers of *Z. kickxii* seem distinctive enough to distinguish the two species easily. The cones of *Z. pygmaea* are an overall dark red-brown whereas those of *Z. kickxii* are greenish with a slight dusting of light red-brown tomentum on the terminal facets. I have not been able to study the two species in their habitat and therefore cannot comment on the variation each may exhibit. There is no doubt that these two are closely related. Both are found in Pinar del Río province in westernmost Cuba.

There are very few examples of *Zamia kickxii* in cultivation outside Cuba. Dividing old, multiheaded plants has produced many of the specimens found in collections. *Zamia kickxii* is easy to grow, trouble-free, and will produce a multiheaded tuber with many leaves in just 3–5 years. It is a small, decorative cycad that serves well as a potted plant or garden subject. The only insect pest that causes any trouble for this little *Zamia* is mealybug. Infestations can be easily eliminated by the application of an oil spray or any insecticide recommended for mealybugs. If infestations are left too long without treatment, the crown of the tuber is often damaged or killed.

There is a lack of data on the conservation status of *Zamia kickxii.* With continuing land clearance for agriculture in Cuba, *Z. kickxii* must be considered endangered.

Zamia lacandona Schutzman & Vovides 1998

PLATES 461–463

The epithet for *Zamia lacandona* refers to the Lacandon or Lacandona rain forest of eastern Chiapas, Mexico, which in turn is named for the Lacandona Indians who inhabit it. Chromosome numbers $2n$ = 16–18. STEMS subterranean, tuberous, 17–40 cm (6.7–16 in) long, 4.5–8 cm (1.8–3.2 in) in diameter. Cataphylls papery, leaf cataphylls deltoid, 22–34 mm (0.9–1.3 in) long, 23–38 mm (0.9–1.5 in) wide, cone cataphylls narrow triangular, lightly tomentose, 28–63 mm (1.1–2.5 in) long, 4–12 mm (to 0.5 in) wide. LEAVES usually solitary, occasionally two, rarely more, erect, arching, 1–1.9 m (3.3–6.2 ft) long, 34–80 cm (13–32 in) wide, emergent leaves lightly tomentose, soon becoming glabrous, reddish brown or purplish brown until mature, then gradually turning green. Petiole semiterete, dark greenish brown, brown tomentose, 70–90 cm (28–35 in) long, 1–2 cm (0.4–0.8 in) in diameter, armed through about 75% of its length with spines 1–4 mm long, base massive and encompassing almost the entire apex of the stem. Leaflets in 7–12 pairs, angled forward about 45°, linear lanceolate to oblanceolate, lower leaflets subfalcate, median leaflets 36.6–42 cm (14.4–17 in) long, 28–55 mm (1.1–2.2 in) wide, the attachment 5–10 mm (0.2–0.4 in) wide and remaining dark brown even after maturing, apex equally to unequally acuminate, margin slightly revolute, with teeth 2–4 mm long in the apical half to two-thirds of the leaflet. FEMALE CONES solitary, erect, barrel shaped, 12–17 cm (4.7–6.7 in) long, 5–7 cm (2–2.8 in) in diameter, densely brown tomentose with light beige terminal facets, apex shortly apiculate. Peduncle 38–50 mm (1.5–2 in) long, 19–22 mm (0.8–0.9 in) in diameter, lightly tomentose. Sporophylls 17–20 mm (0.7–0.8 in) long. Sporophyll face raised hexagonal truncate, 13–20 mm (0.5–0.8 in) high, 22–30 mm (0.9–1.2 in) wide, the terminal facet narrowly hexagonal and sunken. Sarcotesta pinkish red to bright red when ripe. Sclerotesta ovoid, not angular, 16–20 mm (0.6–0.8 in) long, 10–13 mm (0.4–0.5 in) in diameter, light brown, smooth. MALE CONES usually one to three, slightly decumbent but cone erect, peduncle turning erect, 65–74 mm (2.6–2.9 in) long, 18–25 mm (0.7–1 in) in diameter, densely dark beige to light brown tomentose, apex of reduced sporophylls but sometimes shortly apiculate, apiculum 4–5 mm (0.2 in) high, about 7 mm (0.3 in) in diameter. Peduncle decumbent but cone erect, peduncle10–14 cm (4–5.5 in) long, 5–10 mm (0.2–0.4 in) in diameter, lightly tomentose. Sporophylls 5–8 mm (0.2–0.3 in) long. Sporophyll face 2–4 mm high, 5–8 mm (0.2–0.3 in) wide, projecting 2 mm, the terminal facets slightly sunken, lateral facets indistinct. Sporangia in two patches attached to the edge of the sporophyll. HABITAT: Primary rain forest and secondary regrowth such as abandoned cornfields, areas cleared by logging operations, and roadsides. Rainfall is 2000–3000 mm (79–120 in) annually, falling mainly in summer. Temperatures are generally 20–30°C (68–86°F) summer and winter. **Distribution:** Mexico, eastern Chiapas state, Lacandon or Lacandona rain forest.

To my knowledge the first documented gathering of *Zamia lacandona* was in 1968 by three Mexican botanists (J. Chavelas P., G. Alanís, and M. Martínez) collecting in the vicinity of Palenque, Chiapas. Since that time, several other collections have been made by a number of botanists and collectors. I was able to investigate this cycad in its habitat in 1992 and found it to be very scattered but widespread and sometimes locally common throughout the Lacandon rain forest. *Zamia lacandona* naturally occurs in primary rain forest but has been able to survive in areas cleared for farming, logging, or road construction. Its survival has been the result mainly of its underground tuber, which often remains untouched during logging or other forms of land clearance. Even when farmers' plows damage the tubers, they reroot and continue to grow. Evidence of this are the numerous plants growing in old cornfields. Plants growing in these disturbed habitats often cone more regularly because of the increased sunlight to which they are exposed.

Zamia lacandona is most closely related to *Z. purpurea* and *Z. splendens,* more distantly to *Z. cremnophila* and *Z. standleyi. Zamia purpurea* and *Z. splendens* bear the closest resemblance to *Z. lacandona* but may still be easily distinguished from it by leaflet characteristics alone. The leaflets of *Z. lacandona* are falcate, those of *Z. purpurea* and *Z. splendens* not. Whereas *Z. cremnophila* and *Z. standleyi* also have falcate leaflets, their shape is lanceolate as opposed to the obovate leaflets of *Z. lacandona.* The leaflets of *Z. purpurea* have veins somewhat raised on the upper surface, and those of *Z. standleyi* have a fold down the center. The leaves of *Z. lacandona* and *Z. standleyi* are erect and arching, those of *Z. cremnophila* pendent, and those of *Z. purpurea* and *Z. splendens* spreading.

In cultivation, *Zamia lacandona* tends to be somewhat slow growing. It will generally produce only a single large leaf during each growth cycle, but in cultivation there can be more than one cycle per year. The size and beauty of these large leaves make this cycad a worthwhile subject for any collection. The purplish brown color of the emerging leaves is noteworthy, and this color persists on the rachis and underside of the leaflets for many months. Cone production is erratic and undependable. Females usually produce a single erect cone that is brown with tan centers on the individual sporophylls. Males produce several slightly decumbent cones in sequence that are overall light brown to tan.

The conservation status of *Zamia lacandona* seems secure. I found plants over a large area in the Lacandon forest, and this widespread distribution will aid in its conservation. Continuing land clearance, however, will no doubt shrink the range of *Z. lacandona.*

Zamia lawsoniana Thiselton-Dyer 1883b

Zamia lawsoniana is named in honor of Marmaduke Alexander Lawson (1840–1896), British botanist and professor of botany at Oxford University. **Stems** subterranean and tuberous. **Leaves** few, upright, glabrous. Petiole not described. Rachis more or less three-sided. Leaflets in about 25 pairs, long linear lanceolate, slightly curved, rigid, 18–22.5 cm (7.1–9 in) long, 7.5 mm (0.3 in) wide, abruptly narrowed at its base and gradually acuminate toward the apex, margins in dried material slightly revolute, the apical half serrulate on both sides. **Female cones** not described. **Male cones** solitary, ovoid cylindrical, about 63 mm (2.5 in) long and 25 mm (1 in) in diameter, ash gray, apex blunt or rounded. Peduncle "long" (Thiselton-Dyer), gray hairy. Sporophyll face hexagonal with a central depression. Sporangia in a single patch. **Habitat:** Not described. **Distribution:** Mexico, Oaxaca state (?).

When William T. Thiselton-Dyer described *Zamia lawsoniana* in 1883, it was based on an herbarium specimen labeled "Oajaca," Mexico, collected in 1840–1845 by a Dane, C. Jurgensen, and deposited at the Fielding-Druce Herbarium, University of Oxford, England. The original description is so concise that not much can be gleaned from it. The type specimen, *Jurgensen 209,* consists of a leaf and fragments of a male cone. I have studied this specimen and found it to be almost exactly like one collected at El Ocotito, Guerrero, about 78 km (48 miles) inland from Acapulco. That is far removed from the state of Oaxaca but I am not aware of any Oaxacan specimens resembling the type of *Z. lawsoniana.* There is also the possibility that Jurgensen might have been mistaken since he gave no locality other than the state. I checked with the University of Oxford but there are none of Jurgensen's field notes there. What little we can learn from the description and the type specimen places it in the *Z. loddigesii–Z. paucijuga* complex. Thiselton-Dyer did not remark on what distinctive features he based this species, but most of his work on cycads was quite good and we must believe that this specimen was perceived as sufficiently distinct by him. Any further discussion of *Z. lawsoniana* without additional material and habitat data would be conjecture.

Zamia lecointei Ducke 1915

PLATES 464, 465

Zamia obidensis Ducke 1922

Zamia lecointei is named in honor of Paul Le Cointe (b. 1870), a botanist who studied the Amazonian area of Brazil. Chromosome number 2*n* = 16. **Stems** subterranean, tuberlike, younger plants with a single crown and about 20 cm (8 in) long and 6 cm (2.4 in) in diameter, older plants rarely dividing at the apex to form multiple crowns, the old leaf bases and cataphylls soon shed to form a smooth skin. Cataphylls long triangular, stipulate, densely tomentose. **Leaves** usually two to four, about 1.5 m (4.9 ft) long, 56–70 cm (22–28 in) wide. Petiole 50–62 cm (20–24 in) long, sparsely armed with spines 1.2 mm long. Leaflets in 30–39 pairs, median leaflets linear lanceolate, sometimes falcate, 30–37 cm (12–15 in) long, 1–1.5 cm (0.4–0.6 in) wide, rarely as wide as 2 cm (0.8 in), apex long acuminate, margins flat and with two or three small teeth generally on the upper margin. **Female cones** solitary, rarely two, erect, cylindrical, 12–15 cm (4.7–6 in) long, 4–5 cm (1.6–2 in) in diameter, brownish purple, apex conical. Peduncle 10–14 cm (4–5.5 in) long, tomentose. Sporophylls hexagonal, 12 mm (0.5 in) high, 20–25 mm (0.8–1 in) wide, brownish purple tomentose. Sarcotesta red when ripe. Sclerotesta ovoid oblong, 15–17 mm (0.6–0.7 in) long, 10–12 mm (0.4–0.5 in) in diameter, tan, smooth. **Male cones** one to several, 7–10 cm (2.8–4 in) long, 2–2.5 cm (0.8–1 in) in diameter. Peduncle 6–8 cm (2.4–3.2 in) long. Sporophyll face hexagonal, slightly elevated, all seven facets distinct. **Habitat:** Moderately open, low-elevation, dry seasonal forest to tropical lowland wet primary forest, on small hills in rocky soil among boulders, in deep shade. Rainfall is 1800–2200 mm (71–87 in) annually, mainly falling May–December. **Distribution:** Brazil, northeastern part of the country along the Rio Branco de Obidos, a tributary of the Amazon. Venezuela, southern portion of the country along the border with Brazil.

Zamia lecointei was described in 1915 by Adolpho Ducke from specimens collected along the Rio Erepecuru in northern Brazil. In 1922 Ducke described *Z. obidensis,* stating that it was midway between *Z. ulei* and *Z. lecointei* in its leaflet characteristics, that it had a persistent light brown color at the leaflet attachment, and that the number of vertical rows (12–26) on the male sporophylls was distinctive. I have not had the opportunity to study mature plants of *Z. lecointei* or any material of *Z. obidensis,* which was later placed in synonymy under it, and therefore cannot comment on them. Ducke stated that *Z. lecointei* was in cultivation at the Museum Paraense at Belém, Pará, where many of Ducke's herbarium specimens are deposited.

Zamia lecointei is not often found in collections. This may be because it is somewhat difficult to maintain in cultivation. Plants in my collection seem more prone to fungal attacks than other similar species. *Zamia lecointei* is suitable for cultivation in tropical and subtropical climates or greenhouses. It cannot be recommended for temperate climates or anywhere that frost might occur.

I have found no information on the conservation status of *Zamia lecointei.* It does inhabit some remote areas that have not suffered from land clearance, and we may presume that it is relatively safe.

Zamia lindenii Regel ex André 1875

PLATES 466, 467

Aulacophyllum lindenii (Regel ex André) Regel 1876a

Zamia lindenii is named in honor of Jean Jules Linden (1817–1898), who received plants of this cycad from Benedikt Roezl and introduced them into horticulture. Chromosome number 2*n* = 16. **Stems** arborescent, cylindrical, erect, branching usually as a result of injury, to 4 m (13 ft) tall, 17.8–25 cm (7–10 in) in diameter, leaf bases not persistent and the stem forming a somewhat smooth epidermis with age. **Leaves** usually 10–20 or more, arching, bright green, 1.5–2.5 m (4.9–8.2 ft) long, 56–65 cm (22–26 in) wide, flat. Petiole 0.3–1 m (1–3.3 ft) long, 1–1.3 cm (0.4–0.5 in) in diameter, persistently tomentose, the petiole and rachis moderately armed. Leaflets in 40–44 pairs, unevenly and gradually drawn out, bright green above and below, the lower surface somewhat lighter, smooth on upper and lower surfaces, the terminal half with a few scattered teeth, median leaflets 30–35 cm (12–14 in) long, 4–5 cm (1.6–2 in) wide. **Female cones** usually one or two but sun-grown robust plants sometimes producing as many as five, erect at first, pendent below the leaves at maturity, cylindrical, 35–50 cm (14–20 in) long, 8–11.5 cm (3.2–4.5 in) in diameter, densely brown tomentose. Peduncle 8–23 cm (3.2–9.1 in) long, 32–38 mm (1.3–1.5 in) in diameter, reddish brown tomentose. Sporophyll face 3.5–4 cm (1.4–1.6 in) wide, 2–2.5 cm (0.8–1 in) high, the surface reddish brown tomentose, with six distinct lateral facets, the terminal facet concave. Sarcotesta bright orange-red when ripe. Sclerotesta three-sided, 23–30 mm (0.9–1.2 in) long, 13–16 mm (0.5–0.6 in) in diameter, smooth. **Male cones** usually one to four, produced in series, prolonging pollen shedding, erect, cylindrical, 24–32.5 cm (9.4–

13 in) long, 3.5–4.5 cm (1.4–1.8 in) in diameter, densely medium brown tomentose. Peduncle upright, then leaning, 12.5–15 cm (5–6 in) long, 15–18 mm (0.6–0.7 in) in diameter, medium brown tomentose. Sporophyll face 4–5 mm (0.2 in) high, 4–6 mm (0.2 in) wide, with a terminal facet and six distinct marginal facets, the terminal facet sunken. Sporangia in two equal patches separated by a sterile area the same width as the sporangial patches, the sporangia extending to the edges of the sporophyll. **Habitat:** Tropical rain forest understory from sea level to 1100 m (3600 ft). Rainfall averages 1400–3500 mm (55–140 in) annually, mainly falling May–November. **Distribution:** Ecuador, restricted mainly to the coastal plain and the foothills of the Cordillera Occidental, reported from the vicinity of Quevedo, El Entable near Naranjal, between Puente de Chimbo and Bambacagua, and to the east of San Placidó.

Zamia lindenii was described in 1875 by Édouard François André using a name proposed by Eduard August von Regel. The description was based on specimens collected by Benedikt Roezl in Ecuador and grown by the nurseryman Jean Jules Linden. The description was said by André to be based on a living plant, and no type specimen is known to exist. This lack of a type specimen caused Dennis W. Stevenson and Sergio Sabato to designate the illustration in the original description as the neotype.

The closest relative of *Zamia lindenii* appears to be *Z. poeppigiana.* The two cycads generally resemble each other in size, and leaf and leaflet characteristics to some extent. The resemblance is close enough that some taxonomists believe that *Z. lindenii* is a synonym of *Z. poeppigiana.* I have not been able to compare the cones of the two so I cannot say with any authority whether or not they are identical. One factor that bothers me is that about 345 km (215 miles) and the Andes separate the two. This is definitely an instance in which additional specimens and fieldwork are needed. (See comparison under *Z. poeppigiana*.)

Even in habitat *Zamia lindenii* is a remarkably attractive cycad, its trunk often serving as home for a host of epiphytic plants such as ferns and orchids. *Zamia lindenii* becomes sexually mature at a relatively small size, and I have seen numerous coning plants with trunks less than 30 cm (12 in) tall. Cones are produced throughout much of the year but more frequently during the dry season, May–November. Female cones take almost a year to mature and generally hang below the leaves at maturity because of their size and weight. A fully developed female cone may weigh as much as 10 kg (22 pounds) and contain as many as 800 seeds. When male cones begin to shed pollen they produce a fetid odor and attract multitudes of a small beetle, not a weevil, that is no doubt instrumental in transporting the pollen to the female cone.

The only commercial use made of *Zamia lindenii* was in the past when the plants were more common. Occasionally, the leaves were used as decoration, and the dried sap was collected and used as water soluble glue, especially by schoolchildren. From this use came the common name *palma de goma,* glue palm. Strangely enough, this beautiful cycad never became popular as a landscape plant in Ecuador.

Zamia lindenii is one of the larger, more robust species of the genus. Under greenhouse conditions or in tropical to subtropical climates it will grow rapidly from a seedling into a large specimen in very few years. This cycad maintains a large crown of leaves and makes a handsome container plant or garden subject. When grown outdoors it is a beautiful landscape plant, the females holding several pendent cones for long periods of time, adding to the interest. Soil should drain well and be rich in organic material. A light soil mix combined with regular applications of a balanced fertilizer and sufficient heat are all that is needed for good growth. Under greenhouse conditions, infestations of scale insects or mealybugs often cause leaf damage if they are not quickly eradicated. These two insect pests are easily controlled with an oil spray or application of the proper insecticide.

The conservation status of *Zamia lindenii* is not good. At one time *Z. lindenii* was common in Ecuador, but unfortunately, this is no longer so. Because of land clearance, much of its habitat no longer exists. It is estimated that less than 5% of the original habitat of *Z. lindenii* remains (Dodson 1994). The cycad is still relatively abundant in a few scattered areas, but it must be considered endangered as a result of continued clearing of the rain forest.

Zamia lindleyi Warszewicz ex Dietrich 1851

PLATES 468, 469

Zamia lindleyi is named in honor of John Lindley (1799–1865), British botanist and professor of botany at University College, London. Chromosome number $2n = 16$. **Stems** arborescent, erect, cylindrical, 1.8–2.2 m (5.9–7.2 ft) tall, 10–17.5 cm (4–7 in) in diameter, leaf bases soon shed to form a smooth skinlike exterior. **Leaves** 3–15, strongly arching with the apex directed downward, dull medium green, 1.7–2.5 m (5.6–8.2 ft) long, 35–60 cm (14–24 in) wide, reduced in width from midpoint to apex and base, flat. Petiole 0.4–1 m (1.3–3.3 ft) long, 1–1.6 cm

(0.4–0.6 in) in diameter, armed with numerous short stiff spines from the base almost to the apex of the rachis, with two furrows above to the apex. Leaflets in 24–80 pairs, thin textured, subfalcate, narrowly linear lanceolate and drawn out into an almost threadlike apex, angled forward 70–80°, slightly reduced in length from midleaf to base and apex, median leaflets 10–30 cm (4–12 in) long, 1–2.2 cm (0.4–0.9 in) wide, margin entire and slightly revolute. **Female cones** solitary, erect, ovoid to cylindrical, 20–30 cm (8–12 in) long, 8–12 cm (3.2–4.7 in) in diameter. Peduncle about 5 cm (2 in) long, covered with short hairs. Sarcotesta red when ripe. Sclerotesta ovoid, smooth. **Male cones** cylindrical, 10–20 cm (4–8 in) long, 2–3 cm (0.8–1.2 in) in diameter, cream to light yellow to light brown tomentose. Peduncle 3–4 cm (1.2–1.6 in) long, covered with short hairs. **Habitat:** Rain forest at elevations of 600–1200 m (2000–3900 ft), on the Caribbean side and crest of the dividing range where the daily clouds deliver light rain and maintain high humidity. **Distribution:** Panama, Bocas del Toro and Chiriquí provinces, Cordillera Central in the areas adjacent to the Fortuna Valley.

When the German botanist Albert Gottfried Dietrich described *Zamia lindleyi* in 1851 he did so from notes and drawings made by the Polish botanist Józef Ritter von Rawicz Warszewicz. Dietrich stated that besides the notes and drawings, Warszewicz collected plants and seeds that were sent to Germany and England. Evidently no type specimen was collected, or if it was it may have been destroyed during World War II. What we do know is that none of the original living material collected by Warszewicz exists. On this same expedition, Warszewicz collected specimens of another *Zamia* that he said grew communally with *Z. lindleyi.* It was also described by Dietrich in the same publication and given the name *Z. skinneri.* Numerous collections have been made of *Z. skinneri* since Warszewicz discovered it but *Z. lindleyi* has eluded botanists through the years. According to Dietrich's description, *Z. lindleyi* was a large cycad of striking appearance. It seemed very strange that during the years since its discovery it had not been seen again. It was not until the 1980s that Robert L. Dressler realized that the *Zamia* from the Fortuna Valley in Chiriquí province was the long lost *Z. lindleyi.* It is almost a perfect match for the sketch Warszewicz made of *Z. lindleyi* except for the greater number of more crowded leaflets. Dennis W. Stevenson (1993) misidentified *Z. lindleyi* as *Z. chigua,* a species that occurs some 650 km (400 miles) away in the Colombian lowlands. When viewed together there is little doubt as to their close relationship, or their distinctness (Plate 469). I studied *Z. lindleyi* in Panama, and there is no doubt in my mind that it is the plant originally described by Dietrich.

In cultivation, *Zamia lindleyi* is one of the more difficult zamias. It demands a continually moist and acid potting mix and high humidity. Without these requirements the plants are sickly, suffer from tip burn, and generally have an unhealthy appearance. Conversely, well-grown plants are beautiful, distinctive, and a fine addition to any collection.

The conservation status of *Zamia lindleyi* seems secure. The plants have a large area of distribution and are found as scattered individuals or in small colonies. Most of their habitat occurs in a national park, affording them added protection. For these reasons, *Z. lindleyi* may be considered as not threatened.

Zamia loddigesii Miquel 1843a

PLATE 470

Zamia leiboldii Miquel 1847, *Z. loddigesii* var. *leiboldii* (Miquel) A. de Candolle 1868
Zamia loddigesii var. *angustifolia* Regel 1857
Zamia loddigesii var. *obtusifolia* Regel 1857
Zamia leiboldii var. *angustifolia* Regel 1876b, not based on *Z. loddigesii* var. *angustifolia* Regel 1857
Zamia leiboldii var. *latifolia* Regel 1876b
Zamia cycadifolia Thiselton-Dyer 1883b, illegitimate name, not Jacquin 1801 (see *Encephalartos cycadifolius*); *Z. loddigesii* var. *cycadifolia* J. Schuster 1932
Zamia sylvatica Chamberlain 1926
Zamia loddigesii var. *longifolia* J. Schuster 1932

Zamia loddigesii is named in honor of Conrad L. Loddiges (1738–1826), Dutch-born horticulturist who moved to England in 1761 and worked as a nurseryman in Hackney, where he introduced numerous plants from the Americas, and his son, George (1784–1846), who succeeded him. Chromosome number $2n = 18$. **Stems** subterranean, tuberlike, 25–30 cm (10–12 in) long and 5–7.5 cm (2–3 in) in diameter, younger plants with a single crown, older plants dividing at the apex to form multiple crowns, the old leaf bases and cataphylls soon shed to form a smooth skin. Cataphylls triangular, stipulate, sparsely brown tomentose, 4.5–5 cm (1.8–2 in) long, 2–2.5 cm (0.8–1 in) wide. **Leaves** usually two to five, medium green, 75–90 cm (30–36 in) long, 37.5–45 cm (15–18 in) wide, flat, persistently brown tomentose. Petiole green, 17.5–22.5 cm (7–9 in) long, 6 mm (0.2 in) in diameter, moderately to densely armed, the spines sometimes continuing to the apex of the rachis. Leaflets in 16–25 pairs, narrow to broad lanceolate, 21–25 cm (8.3–10 in) long, 1–2 cm (0.4–0.8 in) wide, margin slightly revolute, with scattered small teeth in the apical half to two-thirds of the leaflet. **Female cones** solitary, 7–15 cm (2.8–6 in) long, 4–5 cm (1.6–2 in) in diameter, medium brown tomentose, apex blunt to short apiculate. Peduncle 45–50 mm (1.8–2 in) long, 10–12 mm (0.4–0.5 in) in diameter, densely light brown tomentose. Sporophylls hexagonal, about 1 cm (0.4 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) high, 20–25 mm (0.8–1 in) wide, the facets somewhat indistinct. Sarcotesta orange to orange-red when ripe. Sclerotesta irregularly ovoid, somewhat three-sided, 12–14 mm (0.5–0.6 in) long, 8–9 mm (0.3–0.4 in) in diameter, tan, smooth. **Male cones** one to several, erect until the pollen is shed, cylindrical, 6.5–14 cm (2.6–5.5 in) long, 2–3 cm (0.8–1.2 in) in diameter, densely tan to medium brown tomentose, apex usually blunt but sometimes apiculate. Peduncle 5–7 cm (2–2.8 in) long, 10–12 mm (0.4–0.5 in) in diameter, brown tomentose. Sporophylls about 7 mm (0.3 in) long, densely light brown tomentose, the terminal facets sunken and darker brown. Sporophyll face 2–7 mm (to 0.3 in) high, 7–11 mm (0.3–0.4 in) wide. Sporangia in two groups separated by a sterile area 2–4 mm wide. **Habitat:** Dry to wet semideciduous woodland, usually with oaks dominant, from almost sea level to 1000 m (3300 ft). **Distribution:** Mexico, Veracruz state, coastal areas generally, but ranging inland to Jalapa, Huatsuco de Chicuellas, and Sayula de Alemán, sometimes to the base of the Sierra Madre Oriental.

Zamia loddigesii appears to be widespread and variable, and this has caused considerable taxonomic confusion in the past. Many of the early collections were sterile, and at the time they were collected little was known about the differences in length and width of leaves and leaflets that occur between juvenile and adult plants. This lack of knowledge often led to specimens of the same species being described as different taxa. Such confusion persists even today since many of the early collection areas, having been cleared for agriculture, no longer exist. Within the same colony, individuals can display considerable variation in leaf and leaflet shape and size, size and color of cones, and so on. There is a distinct possibility, however, that two taxa or more may be distinguished in the *Z. loddigesii* complex of Mexico when it has been fully investigated.

Zamia sylvatica, described by Charles J. Chamberlain in 1926 from a single specimen collected near San Juan Bautista Tuxtepec, Oaxaca, was distinguished from *Z. loddigesii* by its unarmed petiole and a pronounced transverse ridge on the megasporophyll. In later years the specimen from which it had been described, which was in cultivation at the University of Chicago, produced spines on the petioles and no longer had the distinctive ridge on the megasporophylls. In 1980–1982 I searched without success in all directions from San Juan Bautista Tuxtepec to find plants that conformed to the description of *Z. sylvatica* but found nothing but *Z. loddigesii.* For these reasons I have included *Z. sylvatica* in synonymy under *Z. loddigesii.*

Zamia loddigesii is not a very exciting or beautiful cycad, and there is nothing remarkable about its three to five long leaves and their long, narrow leaflets. Even so, it is one of the more common species of *Zamia* in cultivation. It is undemanding in its growing conditions and when well established will produce both cones and leaves annually. *Zamia loddigesii* is a good garden plant for warm temperate to tropical climates. If planted where there is any possibility of freezes, it is important to have the tuber completely buried. If the crown is left exposed, it may be damaged by extended freezes, but when fully buried, freezing may destroy only the leaves, which are soon replaced with the advent of warm weather.

If we accept all the forms now included under *Zamia loddigesii,* this species is definitely not endangered, yet a great deal of habitat destruction has occurred over most of the range of this species, from agriculture and cattle ranching. The continued survival of *Z. loddigesii* is doubtless enhanced by its contractile roots and subterranean tuber, which protect the cycad from trampling by cattle and also from the frequent grass fires that occur throughout its range.

Zamia lucayana Britton 1909

PLATE 471

Zamia lucayana, the epithet referring to the Lucaya Indians, who originally inhabited the Bahamas, is called bay rush. Chromosome number not known. **Stems** subterranean, tuberlike, spindle shaped, to 35 cm (14 in) long, 10–15 cm (4–6 in) diameter, in old specimens often branching at the apex to form several crowns, the surface smooth and light brown. **Leaves** four to six, erect, rigid, slightly arching at the apex, dull medium green, to 76 cm (30 in) long, 14–18 cm (5.5–7.1 in) wide when not flattened, strongly keeled, emergent leaves with green leaflets on a brownish rachis. Petiole subterete, slightly flattened above, brownish green, 20–25 cm (8–10 in) long, 5–7 mm (0.2–0.3 in) in diameter, unarmed. Leaflets in 10–15 pairs, opposite or alternate, dull medium green, 14–15 cm (5.5–6 in) long, 1.8–2 cm (0.7–0.8 in) wide, lanceolate to obovate oblong, stiff, narrowing toward the base, conspicuously jointed at the attachment, which is yellow or yellowish green and 3 mm broad, margin thickened, revolute, at the apex unevenly serrulate or lacerate. **Female cones** usually one or two, erect, 10–15 cm (4–6 in) long, 5.8–7 cm (2.3–2.8 in) in diameter, olive green, with a dense overlay of dark brown tomentum. Peduncle erect, 4–5 cm (1.6–2 in) long, 4–5 mm (0.2 in) in diameter, gray to white tomentose. Sporophyll face 1.5–2 cm (0.6–0.8 in) high, 3.3–3.8 cm (1.3–1.5 in) wide, dark brown to blackish brown, lighter at the margins, the facets not distinct. Sarcotesta bright red-orange when ripe. Sclerotesta blunt ovoid, 17–21 mm (0.7–0.8 in) long, 12–15 mm (0.5–0.6 in) in diameter, smooth. **Male cones** as many as seven per crown, 9–13.5 cm (3.5–5.3 in) long, 2–2.8 cm (0.8–1.1 in) in diameter, densely dark brown tomentose, apex of reduced sporophylls. Peduncle 2.5–4.5 cm (1–1.8 in) long, 6–7 mm (0.2–0.3 in) diameter, densely covered with brownish gray tomentum. Sporophylls 8–10 mm (0.3–0.4 in) long. Sporophyll face 5–7 mm (0.2–0.3 in) high, 7–10 mm (0.3–0.4 in) wide, the facets indistinct. Sporangia in two patches separated by a sterile zone 1–3 mm wide. **Habitat:** Generally areas of pure sand, usually under and among sea grape (*Coccoloba*) at elevations of 1–15 m (3–49 ft). Rainfall averages 1000–1500 mm (39–59 in) annually, falling mainly in summer. Temperatures are 20–30°C (68–86°F) summer and winter. **Distribution:** Bahamas, southeastern portion of Long Island.

Zamia lucayana is one of the most decorative of the Caribbean zamias. These plants have a compact habit and in cultivation maintain 6–12 medium green, strongly keeled, upright leaves per crown. The Bahamian habitat of the species is somewhat reminiscent of that of *Z. furfuracea* in southern Veracruz, Mexico. *Zamia lucayana* is difficult to find in its habitat until its preference for sandy areas in stands of sea grape (*Coccoloba*) is noted. Local fishermen advised me that this *Zamia* is found only in sandy areas along the Atlantic coast. Older inhabitants of Long Island, Bahamas, remember when this plant was used as a source of starch. It appears that *Z. lucayana* lives in a symbiotic relationship with the numerous sand crabs that inhabit the area. They eat the fleshy seed coat and scatter the seeds in the process. Judging by the depth of some of the seedlings, 20 cm (8 in), I believe these crabs often carry the seeds into their burrows, where they eventually germinate.

Zamia lucayana grows well in cultivation, and its smaller size makes it a fine pot plant. The short leaves are stiff, upright, and very decorative. It is hoped that propagation of *Z. lucayana* will make it available to collectors and botanical gardens.

Although *Zamia lucayana* is not common in its habitat, it grows in areas not suitable for the cultivation of food crops. This has protected it. Also, the remote nature of Long Island, Bahamas, and the general lack of tourist facilities have protected the area from development. The habitat area is on the windward side of the island, which makes it less desirable to the local populace. Regeneration in habitat is good, and plants can be found in various stages of development. Taking all these facts into consideration, this species does not seem to be threatened. It must be remembered that current conditions might change very rapidly, however, and if that happens there could be a threat to the continued existence of *Z. lucayana* in the wild.

Zamia macrochiera D. W. Stevenson 2002

PLATES 472, 473

The epithet of *Zamia macrochiera* refers to the large glandlike collar separating the leaflet from the petiolule. **Stems** subterranean, tuberous, oblong spheroid to subcylindrical, to 18 cm (7.1 in) long, 10–20 cm (4–8 in) in diameter. Cataphylls long triangular, 3–8 cm (1.2–3.1 in) long, 1–2 cm (0.4–0.8 in) wide. **Leaves** usually one to three, 1–3.5 m (3.3–11 ft) long, 0.9–1.1 m (3–3.6 ft) wide. Petiole 1–2.5 m (3.3–8.2 ft) long, 1–2.1 cm (0.4–0.8 in) in diameter, lightly to densely armed with prickles to 1 cm (0.4 in) long. Rachis often with prickles in lower third. Leaflets in 5–13 (to as many as 30?) pairs, attached to the rachis with a distinctive petiolule 15–19 mm (0.6–0.8 in) long, which is separated from the leaflet by a glandlike collar on its lower surface, median leaflets oblong to long elliptical, 46–56 cm (18–22 in) long, 3–8.6 cm (1.2–3.4 in) wide, somewhat drooping or bent downward from the rachis, margins serrate in the apical third of the leaflet. **Female cones** solitary, cylindrical to ovoid cylindrical, 10–15 cm (4–6 in) long, 4–7 cm (1.6–2.8 in) in diameter, wine red to dark red-brown tomentose. Sarcotesta red. Sclerotesta ovoid, 10–15 mm (0.4–0.6 in) long, 5–8 mm (0.2–0.3 in) in diameter, smooth. **Male cones** solitary (?), cylindrical, 4–6 cm (1.6–2.4 in) long, 1–1.5 cm (0.2–0.3 in) in diameter, cream to tan tomentose. Peduncle 15–30 cm (6–12 in) long. **Habitat:** Understory of primary and secondary rain forest at elevations of 100–300 m (330–1000 ft). Rainfall is generally more than 2000 mm (80 in) annually. The average temperature, summer and winter, is 20–30°C (68–86°F). **Distribution:** Peru, northeastern part of the country, Loreto administrative division, of Maynas province, Río Napo and Río Ampiyacu, in the vicinity of Pebas and Pucaurquillo.

Zamia macrochiera was initially collected some 25 years prior to its description. This species has never been found in large numbers and apparently occurs only as scattered individuals. The lack of sightings may be the result of this species' tall leaves, which are generally encrusted with moss and lichens, making the cycads difficult to see.

Zamia macrochiera is one of only two species of the genus that possess a petiolule with a glandlike collar separating it from the leaflet. The other species with this distinctive leaflet stalk and collar is *Z. manicata* from Colombia and adjacent areas of Panama. *Zamia macrochiera* can be distinguished from *Z. manicata* by its longer leaves, 3 m (9.8 ft) rather than 2 m (6.6 ft), larger cones, and the morphology of the glandlike collar. The collar in *Z. manicata* is only a rimlike structure in contrast to that of *Z. macrochiera,* which has a well-developed flap of tissue that curves up to meet the leaflet, thereby forming a tunnel or open space within. It has been reported that this tunnel often houses colonies of small stinging ants that assist in protecting the leaf from predation.

It is interesting to note that in both *Zamia macrochiera* and *Z. manicata* the petiolule and glandlike collar are absent in seedling leaves, only gradually becoming apparent in juvenile leaves, and well-developed only in adult leaves. It is also remarkable that adult plants, when collected and rerooted, quite often do not produce the petiolule and collar in the first set of leaves.

I am not aware of any specimens of *Zamia macrochiera* in cultivation. Judging by its habitat, *Z. macrochiera* would have to be grown in tropical climates or under greenhouse conditions. Timothy C. Plowman, a member of the *Alpha Helix* Amazon Expedition (1976–1977), collected seedlings of *Z. macrochiera* in May 1977 that were sent to Florida to the Marie Selby Botanical Gardens, Sarasota, and Fairchild Tropical Garden, Miami. Evidently these plants did not survive at either institution because they are no longer there.

The conservation status of *Zamia macrochiera* is not adequately known. It was collected only four or five times in the 25 years prior to its description. In his description, Dennis W. Stevenson states that all collections have been made close to the type locality, and this may indicate that *Z. macrochiera* is a very rare species or that its center of distribution has not yet been discovered. Stevenson also states that this species appears to be threatened by habitat disturbance, and that the type locality was in the process of being converted from secondary forest into a communal garden. Seedlings of *Z. macrochiera* have been observed at the type locality on two occasions, which indicates that reproduction is occurring in spite of the plants being widely scattered. The available data lead me to believe that we must consider *Z. macrochiera* severely threatened.

Zamia manicata Linden ex Regel 1876b

PLATES 474, 475

Zamia madida R. E. Schultes 1958

The epithet for *Zamia manicata* is derived from *manicatus,* Latin for long-sleeved and possibly referring to the petiolule of the leaflet. Chromosome number $2n = 18$. **Stems** subterranean, tuberous, globose to subcylindrical, 10–40 cm (4–16 in) long, 5–7 cm (2–2.8 in) in diameter. Cataphylls numerous, fibrous and leathery, brown, elongate triangular, 5.5–6 cm (2.2–2.4 in) long, 5–10 mm (0.2–0.4 in) wide. **Leaves** usually one to three, erect with the apex arching, dark green, 1–2 m (3.3–6.6 ft) long, 40–60 cm (16–24 in) wide, flat. Petiole robust, erect, deeply grooved above, 0.3–1 m (1–3.3 ft) long, 1–1.5 cm (0.4–0.6 in) in diameter, armed with numerous short spines. Leaflets in 5–12 pairs, elliptical to elliptical lanceolate, glossy green above, paler below, angled forward 30–45°, with a petiolule 2–5 cm (0.8–2 in) long and ending in a glandlike collar where the leaflet attaches, median leaflets 15–35 cm (6–14 in) long, 3–7 cm (1.2–2.8 in) wide, spaced 2.5–3.5 cm (1–1.4 in) apart, margin slightly revolute, serrate in the apical third. **Female cones** solitary, erect, cylindrical, 15–30 cm (6–12 in) long, 4–7 cm (1.6–2.8 in) in diameter, densely red-brown tomentose, apex conical, 7–8 cm (2.8–3.2 in) long. Peduncle erect, 10–15 cm (4–6 in) long, 1–1.5 cm (0.4–0.6 in) in diameter. Sporophyll face hexagonal, 10–13 mm (0.4–0.5 in) high, 20–25 mm (0.8–1 in) wide. Sarcotesta red when ripe. Sclerotesta ovoid to long ovoid, 13–16 mm (0.5–0.6 in) long, 8–10 mm (0.3–0.4 in) in diameter, tan, smooth. **Male cones** usually one to five, cylindrical, 4–6 cm (1.6–2.4 in) long, 1–1.5 cm (0.4–0.6 in) in diameter, densely cream to light brown tomentose. Peduncle 15–30 cm (6–12 in) long, generally decumbent but the cone erect. Sporophyll face elevated, the facets distinct, about 2 mm high and wide. **Habitat:** Primary rain forest and secondary forest at elevations of 100–1000 m (330–3300 ft). Rainfall is very heavy, averaging 3000–5000 mm (120–200 in) annually and falling all year. Temperatures average 25–27°C (77–81°F). **Distribution:** Panama, extreme western Darién province, from Yaviza to the Colombian border. Colombia, northwestern part of the country, from about Mutata, Antioquia department, to the Panamanian border.

Zamia manicata was described by Eduard August von Regel in 1876 from information supplied to him by nurseryman Jean Jules Linden. Apparently, Regel had never seen the plant and relied on Linden for data as well as the choice of specific epithet. In 1932 Julius Schuster placed *Z. manicata* into synonymy under *Z. obliqua,* in the process mixing the characteristics of both species in his description. Because of the confusion caused by Schuster's work, Richard Evans Schultes described *Z. madida* in 1958, which he unknowingly based on the same plants that had originally been used for *Z. manicata.* No type specimen of *Z. manicata* has ever been located in any European herbarium. To rectify this, in 1986 Dennis W. Stevenson and Sergio Sabato designated Regel's 1878 illustration of *Z. manicata* as the neotype (*Gartenflora* 27: pl. 926, fig. e).

Zamia manicata is one of a very few zamias whose leaflets have a petiolule, or leaflet stalk. This stemlike attachment in *Z. manicata* has a prominent glandlike collar where it joins with the leaflet. It is interesting to note that seedling leaves do no display a petiolule or the glandlike collar. These features are not apparent until the fifth or sixth leaf is produced. The only other *Zamia* that displays both the petiolule and collar is *Z. macrochiera* from Peru. *Zamia montana* and *Z. wallisii* also have petiolules but lack the distinctive collar.

Zamia manicata can be somewhat difficult in cultivation, perhaps because it requires constant warm temperature and very high humidity. Even at the Fairchild Tropical Garden, Miami, Florida, *Z. manicata* must be grown in a greenhouse. The Fairchild has been successful in artificial propagation of *Z. manicata* and has had at least one distribution of seed. About 1987 a large quantity of wild-collected seed of *Z. manicata* was exported from Colombia. This seed germinated very well but most of the seedlings produced from it died from fungal infections. This could not be blamed entirely on the propagation practices because several growers had the same problem. When well grown, *Z. manicata* is a striking plant with its upright leaves and long, broad leaflets with their interesting petiolules and collars. Shade is essential for good leaf color as too much sun will cause yellowing.

The conservation status of *Zamia manicata* appears quite secure. Its habitat is remote and covers a large area in which it is quite common. Continuing land clearance in the area of its habitat will no doubt lead to conservation problems, however.

Zamia melanorrhachis D. W. Stevenson in Stevenson & Sabato 2001

The epithet for *Zamia melanorrhachis* is derived from *melano-,* Greek for black or very dark, and *rhachis*, Latin for stem, referring to the dark brown to dark purple leaf rachis. Chromosome number not known. **Stems** subterranean, tuberous, 5–8 cm (2–3.2 in) in diameter. Cataphylls triangular basally, linear lanceolate apically, 2–5 cm (0.8–2 in) long, 1–2 cm (0.4–0.8 in) wide. **Leaves** usually two to five, erect, oblong, about 50 cm (20 in) long. Petiole terete, about 25 cm (10 in) long, dark purple to black when fresh, armed with very small prickles. Rachis terete, 20–30 cm (8–12 in) long, generally armed with very small prickles in the lower half. Leaflets generally in four to seven pairs, papery, lanceolate, acute at the apex, median leaflets 12–15 cm (4.7–6 in) long, 1–2 cm (0.4–0.8 in) wide, margin flat and serrate in the upper two-thirds of the leaflet. **Female cones** solitary, erect, cylindrical to ovoid cylindrical, 5–8 cm (2–3.2 in) long, 3–4 cm (1.2–1.6 in) in diameter, wine red to dark red-brown. Sarcotesta red. Sclerotesta 10–15 mm (0.4–0.6 in) long, 5–8 mm (0.2–0.3 in) in diameter. **Male cones** decumbent or pendent, ovoid, 1–3 cm (0.2–0.6 in) long, 5–10 mm (0.2–0.4 in) in diameter, cream to tan. Peduncle 30–50 cm (12–20 in) long, about 3 mm in diameter. Sporophylls often with one to three sporangia on the upper margins but the greater portion of the sporangia restricted to the lower surface. **Habitat:** Moist to semidry lowland forest. **Distribution:** Colombia, Antioquia and Amazonas departments.

Zamia melanorrhachis is a more recently discovered cycad from two widespread (?) areas in Colombia. Dennis W. Stevenson states that it is found in northern central Colombia, also in Amazonian Colombia. This equates to a spatial separation of approximately 1200 km (740 miles). I find it hard to believe that the same species could have such a separation of its populations. The two populations are stated to have different habitats as well with one occurring in semidry lowland forest, the other in lowland rain forest. It appears that additional fieldwork is needed to assess these discrepancies.

The distinguishing features of *Zamia melanorrhachis* are the dark petiole and rachis and the extremely long, slender peduncles of the male cones. I have not had the opportunity to observe living specimens and therefore cannot comment on the relationships of this species, but it is said to be closely related to another Colombian species, *Z. hymenophyllidia,* whose cones also have unusually long, slender peduncles. Cultivation of *Z. melan-*

orrhachis should be no different from that of other tropical zamias, requiring subtropical to tropical climatic conditions or greenhouse cultivation.

The conservation status of *Zamia melanorrhachis* cannot be assessed because of the lack of sufficient data. It is stated in the original description that *Z. melanorrhachis* "grows well and regenerates in and near native gardens." This gives some hope that *Z. melanorrhachis* might grow well if and when it is brought into cultivation.

Zamia montana A. Braun 1875

Aulacophyllum montanum (A. Braun) Regel 1876a
Zamia kalbreyeri Dammer ex J. Schuster 1932

The epithet for *Zamia montana* is derived from *montanus,* Latin and meaning growing on mountains, referring to this cycad's high-mountain habitat. Chromosome number not known. STEMS arborescent, erect, 1.2–1.5 m (3.9–4.9 ft) tall, rarely as tall as 3 m (10 ft), 22.5–30 cm (9–12 in) in diameter. LEAVES usually four or five, erect, dark green, 1.2–1.5 m (3.9–4.9 ft) long, 60–70 cm (24–28 in) wide, flat. Petiole 20–40 cm (8–16 in) long, about 1.8 cm (0.7 in) in diameter, brown tomentose, soon becoming glabrous, armed throughout its length with minute scattered prickles, base somewhat flattened above and covered with densely tomentose, papery cataphylls 2.5–3 cm (1–1.2 in) long, 1.5–2 cm (0.6–0.8 in) wide. Leaflets in 8–10 pairs, papery, oblanceolate to linear oblanceolate, slightly unsymmetrical, 18–30 cm (7.1–12 in) long, 5–10 cm (2–3.9 in) wide, narrowing at the base to a very short petiolule, apex abruptly acuminate, usually with one prominent tooth and a few smaller teeth, frequently triserrate at the apex, each leaflet with 20–35 parallel veins that are strongly depressed above but not prominent below, margin slightly revolute. FEMALE CONES solitary, cylindrical, 20–30 cm (8–12 in) long, 8–13 cm (3.2–5.1 in) in diameter, densely covered with white tomentum, base of the cone subtended by 10–12 lanceolate, white tomentose cataphylls 12–13.5 cm (4.7–5.3 in) long, 4–5 cm (1.6–2 in) wide at the base. Peduncle cylindrical, 10–15 cm (4–6 in) long. Sporophylls in about 10 vertical rows, individual sporophylls about 2.5 cm (1 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) high, 18–20 mm (0.7–0.8 in) wide. MALE CONES usually in pairs, long conical, 17.5–20 cm (7–8 in) long, 4–5 cm (1.6–2 in) in diameter, tapering toward the apex, capped by a prominent sterile apiculum. Peduncle 10–15 cm (4–6 in) long, 3–4 cm (1.2–1.6 in) in diameter, subtended by about 15 cataphylls about 3 cm (1.2 in) long. Sporophylls in about 20 vertical rows, white to gray tomentose. HABITAT: Moderately shady places in the higher mountain regions at elevations of 2200–2500 m (7200–8200 ft), a cool area often covered by clouds or mists. DISTRIBUTION: Colombia, Antioquia department, restricted to the western Andes.

The very interesting *Zamia montana* was first collected by Gustav Wallis in 1873, then again by Wilhelm Kalbreyer in 1880. The plant dealers Shuttleworth, Carder & Co. of England made the last known exportation of *Z. montana* from Colombia in late 1881 or early 1882. These imported specimens evidently did not take well to cultivation as they all disappeared from collections over the years. The exact habitat locality was lost, and no reported sightings of *Z. montana* were made for more than a century. Then in 1987, *Z. montana* was rediscovered in the western Andes by Diego Restrepo, a Colombian botanist who graciously supplied me with firsthand information about this species. Examples of this cycad have been placed in two Colombian botanical gardens where it is hoped they will flourish and perhaps produce seed for distribution to other gardens.

Remarking on *Zamia montana,* William T. Thiselton-Dyer (1882) gave its closest relative as *Z. skinneri.* He no doubt drew this conclusion from the similarity of leaflet texture, which is somewhat corrugated in both species. The presence of a petiolule (leaflet stalk), however, would indicate that its closest relatives might be *Z. manicata* and *Z. wallisii.* Both those species exhibit this distinctive feature and are also native to the same general region of Colombia, though at considerably lower elevations. *Zamia manicata,* with its smooth leaflet surface, distinctive gland or collar between the petiolule and leaflet, and subterranean tuber, seems to be a somewhat more distant relative than *Z. wallisii. Zamia wallisii* has the same depressed veins, giving the corrugated leaflet surface common to both species, but has fewer pairs of leaflets, generally one to four, that are also considerably larger.

Because of the high elevation of its habitat, there may be certain requirements that make *Zamia montana* difficult to maintain in cultivation. Judging by other high-elevation, cloud forest plants, the greatest difficulty in cultivation is maintaining high humidity and cool temperature. Now that *Z. montana* has been rediscovered, studies of its requirements can be made with the hope of *ex situ* cultivation and possible propagation.

Zamia montana must be considered extremely endangered. The high-elevation woods in which this *Zamia* used to grow were cut and replaced in the 1980s by crops of *Solanum quitoense,* or *lulo* as it is commonly known. This deforestation severely limited the remaining populations of *Z. montana,* and the species is now close to complete extinction. The tragic part of this story is that the *Solanum* crops failed and were abandoned, thus the destruction of *Z. montana* gained nothing in return.

Zamia muricata Willdenow 1806

PLATE 476

Zamia latifolia G. Loddiges ex A. de Candolle 1868, *Z. loddigesii* var. *latifolia* (G. Loddiges ex A. de Candolle) J. Schuster 1932

Zamia verschaffeltii Miquel 1869

Zamia monticola Chamberlain 1926

The epithet for *Zamia muricata* is derived from *muricatus,* Latin and meaning rough with short hard points, possibly referring to the marginal teeth of the leaflets or the spines on the rachis. Chromosome number $2n = 24$. **Stems** subterranean, tuberous, 25–30 cm (10–12 in) long, 7.5–12 cm (3–4.7 in) in diameter, usually with a single crown but often branching with age or as a result of injury. Leaf cataphylls acuminate, 6–7.5 cm (2.4–3 in) long, 2.5 cm (1 in) broad at the base, cone cataphylls long acuminate, 9–11 cm (3.5–4.3 in) long, 2.5 cm (1 in) wide at the base. **Leaves** usually one to six, erect, dark green, glabrous, 1.8–2.2 m (5.9–7.2 ft) long, 55–60 cm (22–24 in) wide, slightly keeled. Petiole stipulate, terete, 62.5–87.5 cm (25–35 in) long, 6–8 mm (0.2–0.3 in) in diameter just below the lowest leaflets, armed with numerous short spines. Leaflets in 16–24 pairs, stiff to flexible, linear lanceolate, gradually and equally acuminate, reduced in length toward the leaf apex, median leaflets 30–35 cm (12–14 in) long, 13–17 mm (0.5–0.7 in) wide, margin serrate in the terminal third to half of the leaflet, not revolute or only slightly so. **Female cones** solitary, at first erect, then leaning, cylindrical, 10–15 cm (4–6 in) long, 4–6 cm (1.6–2.4 in) in diameter, with an apiculate sterile apex. Peduncle 16–28 cm (6.3–11 in) long, 8–10 mm (0.3–0.4 in) in diameter, brown tomentose. Sporophylls 18–20 mm (0.7–0.8 in) long. Sporophyll face more or less hexagonal, 6–8 mm (0.2–0.3 in) high, 15–18 mm (0.6–0.7 in) wide, the terminal facet sunken, lateral facets indistinct. Sarcotesta red when ripe. Sclerotesta thin and papery, long ovoid, more or less three-sided, 12–16 mm (0.5–0.6 in) long, 8–10 mm (0.3–0.4 in) in diameter, light tan, smooth. **Male cones** usually two to five, cylindrical or narrow conical, 6–10 cm (2.4–3.9 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, light gray tomentose. Peduncle 10–23 cm (4–9.1 in) long, 4–6 mm (0.2 in) in diameter, tomentose. Sporophylls 5–8 mm (0.2–0.3 in) long. Sporophyll face hexagonal, 4 mm high, 5–6 mm (0.2 in) wide, gray tomentose. Sporangia in two patches along the sides and sometimes on the upper portions of the sporophyll, lacking on the lower surface. **Habitat:** Tropical deciduous forest at an elevation of about 300 m (1000 ft). The dry season is generally November–April, with sporadic rains May–October. **Distribution:** Venezuela, reported from the foothills of the Cordillera de Mérida, from Puerto Cabello to Mérida, also the vicinity of Caracas, perhaps also extreme northeastern Colombia.

Since its description in 1806, *Zamia muricata* has been relatively common in collections, both public and private. This *Zamia,* though having no aerial stem, does produce a fine crown of tall, upright leaves, making it a fine ornamental for subtropical climates. In its habitat, *Z. muricata* grows in fairly open understory shaded by trees 15–25 m (49–82 ft) tall. The soil is rocky, and this cycad generally grows on hillsides or ridges. There are separate wet and dry seasons.

Zamia verschaffeltii and *Z. monticola* are synonyms of *Z. muricata.* Each was thought by its describer, Friedrich Anton Wilhelm Miquel and Charles J. Chamberlain, respectively, to have originated in Mexico. Neither has been rediscovered in Mexico, nor for that matter has anything remotely resembling either been found there. Both find their closest similarity to *Z. muricata.* The Chamberlain plant was grown from a seed supposedly included with a seed shipment of *Ceratozamia mexicana* collected near Jalapa, Veracruz. Repeated searches in this area have never resulted in the rediscovery of *Z. monticola.*

The juvenile and adult forms of *Zamia muricata* look like two different plants. The younger plants have shorter leaves and broader leaflets. The plants change from year to year until the adult form with its tall, erect leaves and more numerous, narrower leaflets is finally attained. Often with age, as in several other zamias, the stem will branch to form two or more crowns. These multiple crowns result in a greater number of leaves being produced each year and tend to give the plant a more luxuriant appearance.

Zamia muricata grows well in cultivation and will form a robust multiheaded plant in very few years. Growth from seed is rapid, and a coning plant may be produced in 5–6 years. The only consideration in the cultivation of this *Zamia* is the length of the leaves, which because of their size means that the cycad requires considerable space. *Zamia muricata* may be used to good advantage as a background plant or for screening.

From reports I have received, *Zamia muricata* is still relatively common in its habitat. As with most cycads, the colonies may be scattered and very localized. Large colonies still exist, and regeneration is said to be very prolific. The range reported for this species is quite large, therefore *Z. muricata* is not considered to be threatened. Additional fieldwork will be necessary to present a complete analysis of its conservation status.

Zamia neurophyllidia D. W. Stevenson 1993

PLATE 477

The epithet for *Zamia neurophyllidia* is derived from *neuron,* Greek for nerve, and *phyllon,* leaf, referring to the corrugated leaflet surface caused by the sunken veins on the upper side. Chromosome number $2n = 18$. **Stems** arborescent, cylindrical, erect, 0.6–1.5 m (2–4.9 ft) tall, 7.5–10 cm (3–4 in) in diameter, unbranched except through injury, leaf bases not persistent and the stem with age producing a more or less smooth, cream-colored skin. **Leaves** 2–24, spreading, 0.6–1.7 m (2–5.6 ft) long, 46–51 cm (18–20 in) wide, flat. Petiole 25–30 cm (10–12 in) long, 6 mm (0.2 in) in diameter, armed with numerous prickles. Leaflets in 2–10 pairs, angled forward about 90°, with veins depressed above and raised below, producing a somewhat corrugated upper surface, gradually acuminate from midpoint to base, more rapidly acuminate from midpoint to apex, bright glossy green above, lighter below, median leaflets 23–30 cm (9.1–12 in) long, 5.8–7.5 cm (2.3–3 in) wide, margins toothed or with small spines in the apical three-quarters of the leaflet. **Female cones** solitary, infrequently two or three, erect, cylindrical, 21–27 cm (8.3–11 in) tall, 6.5–7.5 cm (2.6–3 in) in diameter, densely rust brown tomentose, inside of the cone pinkish red when seeds ripe. Peduncle 7.5–9.5 cm (3–3.7 in) long, 2–2.5 cm (0.8–1 in) in diameter, densely tomentose. Sporophylls 25–28 mm (1–1.1 in) long. Sporophyll face 13–16 mm (0.5–0.6 in) high, 22–26 mm (0.9–1 in) wide, the facets somewhat indistinct, the terminal facet very small and sunken. Sarcotesta red when ripe. Sclerotesta ovoid, 17–21 mm (0.7–0.8 in) long, 12–15 mm (0.5–0.6 in) in diameter, smooth. **Male cones** 2–10 or more, produced sequentially, erect, cylindrical, 8–9 cm (3.2–3.5 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, densely rust brown tomentose, apex with a blunt sterile cap. Peduncle 57–70 mm (2.2–2.8 in) long, 5–8 mm (0.2–0.3 in) in diameter. Sporophyll face 3–5 mm (to 0.2 in) high and wide, the terminal facet sunken, lateral facets somewhat indistinct. Sporangia in two small groups on the sides of the sporophylls and separated by a sterile area both above and below. **Habitat:** Wet tropical rain forest at elevations of 100–700 m (330–2300 ft), usually among limestone rocks and in close proximity to streams. Rainfall averages 4000 mm (160 in) annually, falling throughout the year. Temperatures average 20–25°C (68–77°F). **Distribution:** Costa Rica, catchment area of the Río Reventazón, south and east to the area around Almirante, Panama.

Zamia neurophyllidia was described in 1993 by Dennis W. Stevenson based on research done by Robert L. Dressler during his many years in Panama. Dressler had found three different forms of *Z. "skinneri,"* two of which he thought might be distinct species. The smallest one was subsequently named *Z. dressleri,* and the midsized plants were described as *Z. neurophyllidia.* The population that *Z. neurophyllidia* was based on is near Almirante, Bocas del Toro province. Since the 1940s, a population of zamias from near Turrialba, Costa Rica, had been misidentified and distributed as *Z. skinneri,* a species considered endemic to Panama. However, this population is quite distinct from the Panamanian plant originally described as *Z. skinneri.* The plants are similar in some respects to *Z. neurophyllidia* and could probably be considered as the northwestern range limit of that species. To my knowledge, however, there are no reports of populations of *Z. neurophyllidia*-like plants in the intervening area. More recent fieldwork in Panama and a critical review of the original description of *Z. skinneri* have brought up the possibility that the Bocas del Toro plants may be the populations on which the name *Z. skinneri* was based. If this proves to be correct it would mean that *Z. neurophyllidia* is a synonym of *Z. skinneri* and that the El Copé populations (considered as Z. skinneri in the present book) may constitute an undescribed species.

The closest relatives of *Zamia neurophyllidia* are without question *Z. dressleri* and *Z. skinneri.* These two species can be distinguished from *Z. neurophyllidia* on the size of their leaflets alone, not to mention the difference in cone dimensions. *Zamia dressleri* has a subterranean tuber, unlike the arborescent stem of *Z. neurophyllidia,* produces a single leaf with only 2–5 pairs of longer, 30–50 cm (12–20 in), and wider, 12–15 cm (4.7–6 in), leaflets. *Zamia skinneri,* like *Z. neurophyllidia,* is arborescent but produces three to six leaves and has 6–10 pairs of longer, 31–56 cm (12–22 in), and wider, 8–20 cm (3.1–8 in), leaflets. Identification of these species is simplified if collection data are available, as I am not aware of overlap in distribution of any of the three. On the other hand, identification of the three in the seedling stage could be very difficult except that *Z. neurophyllidia* has green emergent leaves whereas both *Z. dressleri* and *Z. skinneri* are red-brown emergent.

In cultivation, *Zamia neurophyllidia* demands a tropical to subtropical climate or greenhouse conditions. I have known several people who have tried growing *Z. neurophyllidia* outdoors in southern California with poor results. The plants will survive for several years, except during one of the all too frequent freezes, but they weaken and produce fewer, smaller leaves until their inevitable death. When given the proper climate, they are fast growing and beautiful. With its upright to spreading leaves and its glossy, corrugated leaflets, *Z. neurophyllidia* is without a doubt one of the most handsome of the tropical zamias. For those collectors or public gardens fortunate enough to have plants of both sexes, *Z. neurophyllidia* is reasonably easy to propagate. The female cones remain on the plant almost a year and are quite decorative. Fresh seed germinates almost at once and grows rapidly. Crown rot is all too common in the seedlings, and periodic applications of fungicide is usually necessary to maintain their good health.

Zamia neurophyllidia can be considered threatened. Habitat destruction is the primary cause of decline in the numbers of this species. In Costa Rica, *in situ* conservation of *Z. neurophyllidia* (?) is being promoted by CATIE, the Tropical Agricultural Research and Training Center of Turrialba. This project involves 12 peasant communities where rain forest with natural stands of *Z. neurophyllidia* (?) is being protected and the cycad is being propagated vegetatively and from seed. Other potentially valuable rain forest plants are also protected and propagated on a sustained basis, leading to the ultimate conservation of the rain forest.

Zamia obliqua A. Braun 1875

PLATE 478

The epithet for *Zamia obliqua* is derived from *obliquus,* Latin for oblique and meaning with slanted or unequal sides, apparently referring to the shape of the leaflets. Chromosome numbers $2n = 18, 27$. **Stems** arborescent, cylindrical, 2.5–5 m (8.2–16 ft) tall or more, 7.5–15 cm (3–6 in) in diameter, or a smaller form in Panama, unbranched except when damaged, leaf bases not persistent and when weathered off leaving a more or less smooth epidermis. **Leaves** 5–20 or more, upright, spreading, glossy, glabrous, 1–1.3 m (3.3–4.3 ft) long, 43–51 cm (17–20 in) wide. Petiole round, glabrous, 50–60 cm (20–24 in) long, 6–7 mm (0.2–0.3 in) in diameter, armed with scattered short spines. Leaflets usually in 6–10 pairs, glossy bright green above, duller light green below, median leaflets 10–29 cm (4–11 in) long, 6–8 cm (2.4–3.2 in) wide, margins toothed or with small spines in the terminal half, the teeth becoming more numerous toward the apex. **Female cones** solitary, erect, cylindrical, 15–18 cm (6–7.1 in) long, 6.5–7.5 cm (2.6–3 in) in diameter, densely pale brown to tan tomentose, sterile apex conical. Peduncle erect, 2–3 cm (0.8–1.2 in) long, 1–2.5 cm (0.4–1 in) in diameter, tomentose. Sporophyll face truncate or slightly concave, 1 cm (0.4 in) high, 2.5–3 cm (1–1.2 in) wide. Sarcotesta red-orange when ripe. Sclerotesta 20–24 mm (0.8–0.9 in) long, 15–17 mm (0.6–0.7 in) in diameter, somewhat triangular in cross section, light tan, smooth. **Male cones** usually one to three, erect, 19–27 cm (7.5–11 in) tall, 4–5 cm (1.6–2 in) in diameter, tan tomentose, the terminal facet and sporophyll margins sometimes darker brown. Peduncle erect, 3–6 cm (1.2–2.4 in) long, 12–18 mm (0.5–0.7 in) in diameter, finely red-brown tomentose. Sporophyll face 6–10 mm (0.2–0.4 in) high, 7–12 mm (0.3–0.5 in) wide, projecting about 4 mm, the facets distinct. Sporangia in a single patch covering the lower surface and sides, sometimes continuing across the upper front margin of the sporophyll. **Habitat:** Low, seasonally wet, coastal rain forest, in dense shade, generally at elevations of 10–20 m (33–66 ft) but some populations above 600 m (2000 ft). Annual rainfall averages 5000–7000 mm (200–280 in), falling mainly in summer. Temperatures are 20–30°C (68–86°F) or more, summer and winter. **Distribution:** Colombia, Chocó department and coastal areas from Cabo Corrientes north to Bahía Solano. Panama, Darién province, area surrounding Yaviza.

Berthold Seemann discovered what would become *Zamia obliqua* in 1847 while serving as botanist aboard H.M.S. *Herald.* The *Herald* had been commissioned by the English government to search for the last expedition of Sir John Franklin, presumed lost along the western polar shores of the American continent. On the way north after rounding Cape Horn, a stop was made by the *Herald* in New Granada (now Colombia), where Seemann found the cycad at Cabo Corrientes. In 1873 Gustav Wallis, a plant collector for the James Veitch nursery in England, collected it at the same locality. The German botanist Alexander Carl Heinrich Braun described *Z. obliqua* in 1875, based on the plants collected by Wallis.

Zamia obliqua is one of the most beautiful species of the genus. It has a very palmlike habit with a tall, slender stem and a crown of glossy, bright green, spreading, and arching leaves. There appear to be two forms of this species, if indeed they are the same species. Plants from the type locality at Cabo Corrientes, Colombia, are quite large with stems to 5 m (16 ft) tall or more and leaves to 1.25 m (4.1 ft) long. The form from Panama, at least as an immature plant, is a little gem with stems about 1 m (3.3 ft) tall and 2.5 cm (1 in) in diameter, crowned with numerous leaves only about 40 cm (16 in) long. It actually looks more like a beautiful little palm than a cycad. Mature plants in the area are said to reach a height of as much as 5 m (16 ft). I have found no records indicating that the two populations overlap or even come into close contact with each other. In fact, the spatial separation between them is about 275 km (170 miles). The leaflets of the two forms are dissimilar with the Panamanian ones measuring 5–10 cm (2–3.9 in) long, 3–6 cm (1.2–2.4 in) wide, as opposed to 20–29 cm (8–11 in) long, 7–8 cm (2.8–3.2 in) wide, in the Colombian form. This is a case in which additional fieldwork and more specimens are needed to clarify the taxonomic situation.

The horticulture of *Zamia obliqua* is simple in a tropical to subtropical climate and a shaded location. It has proven to be undemanding when given the proper conditions, and an arborescent stem is soon formed even from a seedling. I have grown three plants of *Z. obliqua* about 20 years. They were started from cuttings 7.5 cm (3 in) long, brought to me from Cabo Corrientes, Colombia. They grew to have stems more than 60 cm (24 in) tall, and the males began coning after about 14 years. There are two males and a female, and the female started coning about 5 years later. I hope to produce viable seed using these plants.

Because of its growth habit, *Zamia obliqua* makes an exquisite pot plant for the conservatory or house. This cycad is unexcelled as a houseplant, especially the Panamanian form with its small size. When new foliage is produced, however, the plant should be returned to the greenhouse until leaves have matured and hardened. Then it can be moved back into the house. As with most plants, this cycad has some problematic attributes as well. First, as a tropical species it must be given a warm, humid atmosphere for best results. Second, and more important, is that plants and seeds are difficult to obtain. If this shortage of propagation material is overcome, I have no doubt that *Z. obliqua* will become one of the most popular zamias in horticulture.

The conservation status of *Zamia obliqua* in Colombia is secure with numerous populations ranging over a relatively large area. The Panamanian form also covers a large area and is locally common. The reported clearing for crops, happening in most Central and South American countries, poses a continuing problem.

Zamia paucijuga Wieland 1916

PLATE 479

The epithet for *Zamia paucijuga* is derived from *pauci-,* Latin for few, and *-jugus,* paired, and meaning few leaflets, referring to the type specimen, which had only three pairs of leaflets. Chromosome numbers 2*n* = 23, 24, 26–28. **Stems** subterranean, tuberous, 15–25 cm (6–10 in) long, 7.5–10 cm (3–4 in) in diameter, usually single crowned but older plants sometimes with two or more crowns. Cataphylls gradually acuminate, about 3 cm (1.2 in) long and 2 cm (0.8 in) wide at the base. **Leaves** one to six, usually two or three in mature plants, upright and arching, light green, 67.5–72.5 cm (27–28 in) long, 31–37 cm (12–15 in) wide, flat. Petiole stipulate, 20–22.5 cm (8–9 in) long, 6–8 mm (0.2–0.3 in) in diameter, armed with infrequent spines 2–3 mm long. Leaflets in 10–23 pairs, angled forward about 30°, more or less flatly inserted on the rachis, median leaflets 17.5–20 cm (7–8 in) long, 12–15 mm (0.5–0.6 in) wide, margin on the lower half of the leaflet generally entire, the upper half toothed toward the apex. **Female cones** usually solitary, rarely two or more, erect, ovoid to cylindrical, 8–12 cm (3.2–4.7 in) long, 4.5–5 cm (1.8–2 in) in diameter, tan to light brown. Peduncle 30–50 mm (1.2–2 in) long, 12–15 mm (0.5–0.6 in) in diameter, brown tomentose. Sporophyll face 1–1.5 cm (0.4–0.6 in) high, 2–2.5 cm (0.8–1 in) wide, the facets prominent. Sarcotesta red-orange when ripe. Sclerotesta somewhat three-sided, narrow ovoid, 13–15 mm (0.5–0.6 in) long, 8–10 mm (0.3–0.4 in) in diameter, light tan, smooth. **Male cones** one or more per crown, ovoid to cylindrical, 7.5–12.5 cm (3–4.9 in) long, 2–2.5 cm (0.8–1 in) in diameter, light brown to tan, apex conical. Peduncle 5–7.5 cm (2–3 in) long, 5–8 mm (0.2–0.3 in) in diameter. Sporophyll face about 3 mm high and 5 mm (0.2 in) wide. **Habitat:** Low-elevation coastal dry thornbush. Rainfall is about 2000 mm (79 in) annually, falling mainly in summer. **Distribution:** Mexico, Oaxaca state, originally described from Puerto Miniso (Minizo) on the Pacific coast, some taxonomists considering all the western coast zamias to be *Zamia paucijuga* and if so, from Nayarit to Chiapas, including a colony on María Cleofás, the southernmost island of the Tres Marías, but I believe there are several species on Mexico's western coast.

When George Reber Wieland (1916) described *Zamia paucijuga* as a new species in *American Fossil Cycads,* the description was so concise as to be almost useless. The entire description is only three sentences long and is accompanied by an outline of a leaf consisting of three pairs of leaflets. This illustration is almost certainly of an immature leaf though Wieland stated that the plant's tuber was 8 cm (3.2 in) in diameter. I have visited the type locality in Oaxaca, Mexico, but was unable to locate *Z. paucijuga* there. There is a good possibility that the habitat where the type was collected no longer exists since most of the land has been cleared. Judging by the zamias found to the north and south of the locality, which conform, to a degree, with typical *Z. loddigesii* of the eastern coast, the leaf illustrated by Wieland must surely be immature. Plants collected about 24 km (15 miles) northeast of the type locality, near Santiago Jamiltepec, Oaxaca, produce leaves as long as 1 m (3.3 ft) with about 23 pairs of leaflets that are much longer and narrower than those of the type. The stem, leaf, and cone measurements given for *Z. paucijuga* in here are taken from plants collected near Santiago Jamiltepec.

Some years ago I heard rumors of cycads on the Tres Marías, islands about 100 km (60 miles) off the western coast of Mexico. In 1963 I chartered a sailing boat to take me to these islands to look for them. We spent 2 weeks searching the islands. The first and largest island, María Madre, is the only inhabited one in the group. It is a dry desert island and the location of one of Mexico's penal colonies. It proved to have no cycads. Sailing south, we came next to María Magdalena, a steep-sided island covered with deciduous hardwood forest. Exploration of this island was made difficult first by the rocky coastline and heavy surf, which made landing our skiff more than a little dangerous, then by the steep terrain, covered with thick forest and thorny vines. There, also, no zamias were found. The last island, María Cleofás, was also our last chance at finding the elusive cycads. We sailed into a beautiful coral lagoon, where we anchored. The lagoon was surrounded by a narrow sandy beach, which made landing our skiff a pleasure. Only a few steps into the forest and we found ourselves standing in the midst of hundreds of zamias! The next 2 days were spent studying the zamias and exploring the island. The zamias were large plants and were very common in the forest understory. These zamias are included in *Zamia paucijuga* and are a very robust form of the species.

Along the west coast of Mexico from about San Blas, Nayarit, south to the Guatemalan border, there are many populations of zamias all of which are now considered part of the *Zamia paucijuga* complex. Within this range there are numerous leaf sizes and leaflet shapes displayed. There is such a great deal of variation within this group I find it very hard to believe they are all the same species. The western coast of Mexico is not well explored in regard to its cycad flora, and I feel more work is necessary to properly document it. Hopefully this will take place in the not too distant future.

The following horticultural notes are based on plants from Santiago Jamiltepec and San Gabriel Mixtepec, Oaxaca. Although *Zamia paucijuga* is not difficult to grow, it tends to be intolerant of frost. When planted outdoors in a temperate climate, as in southern California, leaf burn will occur in all but the mildest of winters. If it is necessary to plant the species in a garden environment, the stem should be planted with its crown somewhat below the soil surface. That way, the stem is protected from freezing, and even if defoliated, it will generally produce new leaves when the weather starts to warm in the spring. As with most zamias, this species prefers a loose, well-drained soil rich in humus. Seedlings grow rapidly, and a coning plant can usually be produced in less than 5 years. As an ornamental, *Z. paucijuga* is not very striking. Larger specimens could easily be mistaken for a *Ceratozamia* in some cases, though the leaves of *Z. paucijuga* are generally lighter green and have marginal teeth. Generally, it is a species without a great deal to recommend it for ornamental use.

The conservation status of *Zamia paucijuga* is secure if we accept all the western Mexican coast populations as this species; it does not appear to be threatened. Colonies are numerous and occur on poor land that is not easily farmed. Regeneration is good, and numerous small plants may be seen in most colonies.

Zamia poeppigiana Eichler 1863

PLATE 480

Zamia parasitica Poeppig ex Eichler 1863, as a synonym, illegitimate name

Zamia poeppigiana is named in honor of Eduard Friedrich Poeppig (1798–1868), German botanist, zoologist, and explorer who discovered this cycad during his trip to Brazil and Peru, 1829–1832. Chromosome number not known. **Stems** prostrate, creeping, 1.5–2.5 m (4.9–8.2 ft) long, 15–25 cm (6–10 in) in diameter, often growing on fallen tree trunks and appearing parasitic, sometimes erect, the surface at first showing scars of old leaf bases, then becoming more or less smooth with age. **Leaves** usually 10–20, erect to spreading, rich green and glabrous, 1.1–2.5 m (3.6–8.2 ft) long, 30–70 cm (12–28 in) wide, flat. Petiole glabrous, acutely triangular to subtriangular in cross section, 20–40 cm (8–16 in) long, about 12 mm (0.5 in) in diameter, unarmed or with scattered spines. Leaflets in 20–40 pairs, glossy rich green, flexible, lanceolate, broadly falcate, acute, spaced 2–2.5 cm (0.8–1 in) apart, median leaflets 15–35 cm (6–14 in) long, 2–4 cm (0.8–1.6 in) wide, margins serrate, more so at the apex and on the lower side, narrowed at the attachment to 8–10 mm (0.3–0.4 in) wide. **Female cones** usually solitary, erect, cylindrical, 25–35 cm (10–14 in) long, 8–11 cm (3.2–4.3 in) in diameter, densely gray-brown tomentose, cones reported to be ripe in May–July. Peduncle 6–8 cm (2.4–3.2 in) long, 2–2.5 cm (0.8–1 in) in diameter. Sporophyll face hexagonal, 12–15 mm (0.5–0.6 in) high, 25–30 mm (1–1.2 in) wide. Sarcotesta red when ripe. Sclerotesta ovoid, 25–30 mm (1–1.2 in) long, 13–20 mm (0.5–0.8 in) in diameter. **Male cones** solitary, erect, long cylindrical, 18–27 cm (7.1–11 in) long, 2–4 cm (0.8–1.6 in) in diameter, apex truncate. Peduncle 5–7 cm (2–2.8 in) long, 1.5 cm (0.6 in) in diameter, tomentose. Sporophylls in 14 vertical rows of more than 50 each. Sporophyll face hexagonal, truncate, 4–7 mm (to 0.3 in) high, 5–8 mm (0.2–0.3 in) wide, projecting, the facets distinct. Sporangia in two patches of about 14 sporangia each and separated by a distinct ridge. **Habitat:** Shady, moist woods, often on fallen and decaying tree trunks, at elevations of 300–1000 m (980–3300 ft). Rain falls at almost any time of year and the climate is hot and humid. **Distribution:** Peru, Maynas Alto province, along the Río Tocashe. Colombia (?), southwestern region of the country near Buenavista and Barbacoas, Nariño department.

Zamia poeppigiana, though described in 1863, is not much better known today than it was then. Even now, *Z. poeppigiana* is rare both in living collections and herbaria. This remarkable cycad is said to have a preference for growing on fallen, decaying tree trunks and for this reason was called *Z. parasitica* by Eduard Friedrich Poeppig, who discovered it along the Río Tocashe in Peru. Because the trees on which it grows are dead, it would be more correct to refer to it as an epiphyte than as a parasite. It is doubtful that the collections from Colombia, identified as *Z. poeppigiana,* are assignable to this species. Apart from the great distance separating the two locations, the Colombian plant differs considerably from *Z. poeppigiana* in its growth habit and morphology.

There is a feeling among some taxonomists that *Zamia lindenii* and *Z. poeppigiana* are the same species. I cannot agree for the following reasons. Plants I have in cultivation appear somewhat similar in leaf and leaflet characteristics, but leaflets of *Z. poeppigiana* are more falcate, flat, darker green, and emergent leaves are brownish green, glossy, and glabrous, whereas those of *Z. lindenii* are light green and densely brown tomentose. The female cones of *Z. poeppigiana* are upright whereas those of *Z. lindenii* are pendent.

Although I have scant data on *Zamia poeppigiana* in cultivation, it does respond well to conditions proven optimal for other tropical zamias. Its reported preference for rotting wood may indicate a need for more organic material in the potting mix. An epiphyte mix such as that used for *Z. pseudoparasitica* would no doubt work well.

There are no data available on the conservation status of *Zamia poeppigiana,* but because of the continued and rapid destruction of rain forest throughout South America, it would be prudent to consider it endangered.

Zamia polymorpha D. W. Stevenson, Moretti & Gaudio 1995–1996

PLATE 481

The epithet for *Zamia polymorpha* is derived from *poly-,* Greek for many, and *morphe,* form, and referring to this cycad's extreme variability. Chromosome numbers $2n$ = 17, 22–28. **Stems** subterranean, tuberous, subglobose, to 10 cm (4 in) in diameter. Cataphylls ovate, 3–4 cm (1.2–1.6 in) long, 1.5–2.5 cm (0.6–1 in) wide. **Leaves** usually two or three, erect to spreading, 0.5–1.5 m (1.6–4.9 ft) long. Petiole 15–50 cm (6–20 in) long and lightly to heavily armed. Leaflets in 3–12 pairs, lanceolate to oblanceolate, leathery, median leaflets 20–30 cm (8–12 in) long, 2–8 cm (0.8–3.2 in) wide, margin serrate in the upper two-thirds. **Female cones** solitary, cylindrical to ovoid cylindrical, 10–15 cm (4–6 in) long, 5–7 cm (2–2.8 in) in diameter, tan to brown tomentose. Sarcotesta red when ripened. Sclerotesta 15–20 mm (0.6–0.8 in) long, 5–8 mm (0.2–0.3 in) in diameter, light tan. **Male cones** solitary, cylindrical to ovoid cylindrical, 6–10 cm (2.4–3.9 in) long, 2–4 cm (0.8–1.6 in) in diameter, densely tan tomentose. Peduncle 2–4 cm (0.8–1.6 in) long. Sporophyll face of six slightly inclined facets surrounding a small, centrally depressed, terminal facet. Sporangia present only on the lower surface of the sporophyll. **Habitat:** Generally, flat to slightly hilly areas, in full sun or shade. **Distribution:** Mexico, Yucatán Peninsula. Belize, eastern coast from sea level to about 500 m (1600 ft) along the eastern slope of the Maya Mountains.

Zamia polymorpha has in the past been mistaken for *Z. loddigesii,* which it closely resembles in many respects. Dennis W. Stevenson stated that it resembles *Z. loddigesii* in growth habit, number of leaves, leaf shape and size, and leaflet size and texture. He also stated, however, that both female and male cones of *Z. polymorpha* differ from those of *Z. loddigesii* in overall shape, color, and morphology of the individual sporophylls. The male cones of *Z. loddigesii* are brown when shedding pollen and have sporophylls with a large terminal facet that obscures the lateral facets. Those of *Z. polymorpha* are light tan to tan and have sporophylls with a small terminal facet and six prominent lateral facets. The female cone of *Z. loddigesii* is cylindrical, gray to light tan, and has a prominent extension at its apex. That of *Z. polymorpha* is ovoid, tan to brown, and has a gradually acute apex.

In cultivation, *Zamia polymorpha* has proven to be easily grown. I have had specimens from Belize in my collection for more than 10 years and they have been problem-free. These cycads cone freely in cultivation and seeds are easily set.

Zamia polymorpha must be considered as not threatened because of its wide distribution and the numbers in habitat. The land upon which this cycad grows is generally poor and not fit for agricultural crops.

Zamia portoricensis Urban 1899

PLATE 482

The epithet for *Zamia portoricensis* refers to Puerto Rico, this cycad's place of origin. Chromosome number 2*n* = 16. **Stems** subterranean, tuberlike, 20–25 cm (8–10 in) long and 5–6.5 cm (2–2.6 in) in diameter, younger plants with a single crown, older plants sometimes dividing at the apex to form multiple crowns, the old leaf bases and cataphylls soon shed to form a smooth skin. Cataphylls long triangular, stipulate, densely brown tomentose. **Leaves** usually two to five, glabrous, spreading, medium green, 0.8–1.5 m (2.6–4.9 ft) long, 47.5–57.5 cm (19–23 in) wide, flat to slightly keeled. Petiole brownish green, 20–25 cm (8–10 in) long, 3–6 mm (to 0.2 in) in diameter, unarmed. Leaflets in 20–26 pairs, linear lanceolate, very gradually acuminate, slightly concave, median leaflets 23–31 cm (9.1–12 in) long, 5–7 mm (0.2–0.3 in) wide, margin flat and entire or with one to three small teeth at the apex. **Female cones** solitary, at first erect, later leaning, cylindrical, 10–12 cm (4–4.7 in) long, 6–7 cm (2.4–2.8 in) in diameter, densely gray-brown tomentose, apex blunt and formed of reduced sporophylls. Peduncle densely tomentose, 1.5–2 cm (0.6–0.8 in) long, 1 cm (0.4 in) in diameter. Sporophylls about 2.5 cm (1 in) long. Sporophyll face hexagonal, 12–18 mm (0.5–0.7 in) high, 25–30 mm (1–1.2 in) wide. Sarcotesta red to red-orange when ripe. Sclerotesta globose to ovoid, 15–17 mm (0.6–0.7 in) long, 12–14 mm (0.5–0.6 in) in diameter, tan, smooth. **Male cones** one to several, erect until the pollen is shed, 9–10.5 cm (3.5–4.1 in) long, 2.5–3 cm (1–1.2 in) in diameter, densely medium brown tomentose, apex blunt, composed of reduced sporophylls. Peduncle 15–25 mm (0.6–1 in) long, 8–13 mm (0.3–0.5 in) in diameter, brown tomentose. Sporophylls 10–13 mm (0.4–0.5 in) long. Sporophyll face 5–7 mm (0.2–0.3 in) high, 6–10 mm (0.2–0.4 in) wide, densely tomentose. Sporangia in two patches separated by a sterile zone 3–4 mm wide. **Habitat:** Subtropical moist forest, on predominantly limestone hills in heavy but permeable clay soils. Rainfall averages 1500 mm (59 in) annually, falling in summer. The climate is wet and warm with high temperatures to 35°C (95°F) and lows to about 10°C (50°F). **Distribution:** Puerto Rico, southwestern region of the island, known only from the area of the Susua Forest, extending to the coast.

Zamia portoricensis, described by Ignatz Urban in 1899, is one of the few zamias whose habitat or identification has not caused confusion. In the years since its description, the only taxonomic change in the cycads of Puerto Rico was the naming of *Z. amblyphyllidia.* That change had no affect on *Z. portoricensis* as *Z. amblyphyllidia* had been previously mistaken for *Z. latifoliolata* (= *Z. pumila*), and the latter's shorter, broader leaflets make it easily identifiable.

In cultivation, *Zamia portoricensis* is best suited to subtropical or warm temperate climates. It is one of the easiest zamias to grow and is a fine garden plant to use in small spaces. This cycad, with its broad, arching leaves and stiff, narrow leaflets, does equally well in sun or shade. Mature plants cone yearly and females are easily fertilized. Seedlings grow rapidly, and plants of coning size may be grown in as little as 3 years. If these cycads are allowed to become stressed from too little light or lack of water, they often become infested with scale insects or mealybugs. Such infestations are easily treated and plants soon recover.

The conservation status of *Zamia portoricensis* is reasonably safe. Some habitat loss through land clearance has occurred but there are still sizable populations, some of which occur in protected forest areas. Regeneration in habitat is good, and seedling survival is at acceptable levels. For these reasons, *Z. portoricensis* can be classified as vulnerable.

Zamia prasina W. Bull 1881

PLATE 483

The epithet for *Zamia prasina* is derived from *prasinus,* Latin for leek green, referring to the bright grass green leaves. Chromosome number not known. **Stems** subterranean and tuberous or arborescent, often decumbent, to 30 cm (12 in) long and 10 cm (4 in) in diameter, rarely branching except where damaged. Cataphylls ovate, 3–4 cm (1.2–1.6 in) long, 1.5–2.5 cm (0.6–1 in) wide at the base. LEAVES generally three to six, arching, 50–100 cm (20–39 in) long, 27.5–35 cm (11–14 in) wide, flat. Petiole 15–30 cm (6–12 in) long, slightly grooved above, sparsely to densely armed with small prickles to the lowest leaflets but usually not beyond them. Leaflets in 12–18 pairs, oblong to oblanceolate, apically acute to acuminate, glossy bright green, median leaflets 15–20 cm (6–8 in) long, 4–6 cm (1.6–2.4 in) wide, margin serrate to finely toothed in the apical two-thirds. FEMALE CONES solitary, cylindrical to ovoid cylindrical, 10–15 cm (4–6 in) long, 5–7 cm (2–2.8 in) in diameter, densely cream to tan tomentose when immature, green and glabrous when mature. Sarcotesta light red to deep red. Sclerotesta 15–20 mm (0.6–0.8 in) long, 5–8 mm (0.2–0.3 in) in diameter. MALE CONES cylindrical to ovoid cylindrical, 6–10 cm (2.4–4 in) long, 2–4 cm (0.8–1.6 in) in diameter, densely tan tomentose. Peduncle 2–4 cm (0.8–1.6 in) long. HABITAT: Wet cloud forest on steep slopes and cliffs, sometimes in limestone sinkholes. DISTRIBUTION: Belize, southern part of the country adjacent to Honduras.

Zamia prasina was described by William Bull in 1881 in his catalog, a listing of new horticultural introductions. For some reason both the description and type specimen were mislaid, and the species was not mentioned again until 1932, when Julius Schuster listed it as a synonym of *Z. loddigesii* var. *latifolia* (= *Z. muricata*). Dennis W. Stevenson and Sergio Sabato (1986) accepted Schuster's treatment because neither the description nor type of *Z. prasina* could be located. It was not until 1998 that the original description and type specimen of *Z. prasina* were discovered in the herbarium of the Royal Botanic Gardens, Kew.

I first became aware of *Zamia prasina* when I observed specimens at the Fairchild Tropical Garden, Miami, Florida, that had been collected in southern Belize by Stanley Kiem, former superintendent of the garden. Even in 1980 it appeared to me to be distinct from any of the other zamias that had been collected in Central America. In 1999, in the garden of Dale Holton, Lake Worth, Florida, I once again observed specimens of this same *Zamia.* Holton had taken a number of photographs of the cycad in its habitat, which showed it to be closely related to *Z. tuerckheimii* of western Guatemala. It was only a month later that I learned of the discovery at Kew.

Zamia prasina is interesting with its arching, glossy leaves and its arborescent stem. The leaflets have a distinctive fold running their entire length. This feature is also shared with *Z. standleyi* and *Z. tuerckheimii,* which appear to be close relatives of *Z. prasina. Zamia standleyi* differs from *Z. prasina* in its completely subterranean stem, its narrower, very gradually acuminate leaflets, and its smaller number of leaves, generally only one or two. *Zamia tuerckheimii* differs from *Z. prasina* in its broader leaflets without marginal teeth, its larger stem, and its greater number of leaves.

Zamia prasina apparently requires very specialized habitat conditions. It has only been found in small colonies on steep slopes or cliffs on mountaintops in wet cloud forest. One colony has been found in a large limestone sinkhole, where it grows on the bottom and steep rocky sides. The colonies are generally small, and seedling regeneration is uncommon.

In cultivation, *Zamia prasina* appears to be easily maintained. It is best suited for tropical to subtropical climates but may prove adaptable to warm temperate areas as well. *Zamia prasina* apparently has a very slow growth rate, and plants of any size in the wild must be very old. The growth rate will no doubt prove to be considerably more rapid in cultivation when plants are given occasional applications of fertilizer, and brighter light. Coning appears to be much more frequent in cultivation than in habitat, no doubt the result of brighter light.

The conservation status of *Zamia prasina* cannot be properly assessed. The species is known from only a handful of collections made during more than a century. Judging from the small size of the colonies and the lack of seedling regeneration, *Z. prasina* must be considered threatened. Additional fieldwork will be required to document not only the distributional range but also the population numbers of *Z. prasina.*

Zamia pseudoparasitica J. Yates in Seemann 1854

PAGE 288, PLATES 484–487

The epithet for *Zamia pseudoparasitica* is derived from *pseudo-,* Greek for false, and *parasiticus,* Latin for parasitic, referring to this cycad's being an epiphyte, like many orchids and bromeliads, not a parasite. Chromosome number $2n = 16$. STEMS 30–60 cm (12–24 in) long, rarely as long as 1 m (3.3 ft), 10–15 cm (4–6 in) in diameter, usually covered with persistent leaf bases that give the stem a heavier appearance, and covered with adventitious roots attaching the stem to the surface of the host tree. LEAVES usually 3–10, hanging down at an angle of about 45° or more from the plant, 2–3.5 m (6.6–11 ft) long, 40–50 cm (16–20 in) wide, emergent leaves light brown and almost glabrous. Petiole semiterete, 0.3–1 m (1–3.3 ft) long, 1–1.3 cm (0.4–0.5 in) in diameter, usually unarmed but occasionally with some small scattered spines, with a swollen base covered with persistent light tan tomentum. Rachis gradually diminishing in size from the first leaflets toward the apex, where it ends in a sharp point that extends beyond the terminal leaflets 9–13 cm (3.5–5.1 in). Leaflets in 14–32 pairs, distinctively gray green, leathery and flexible, somewhat falcate, median leaflets 35–40 cm (14–16 in) long, 3–4.5 cm (1.2–1.8 in) wide, margin revolute and entire. **Female cones** solitary, erect to hanging, 17.5–25 cm (7–10 in) long, 10–11.5 cm (4–4.5 in) in diameter, cream to tan tomentose, apex truncate. Peduncle not visible, the cone appearing sessile. Sporophylls 3–3.5 cm (1.2–1.4 in) long. Sporophyll face 2–2.5 cm (0.8–1 in) high, 3.5–5 cm (1.4–2 in) wide, densely tan tomentose, with three distinct upper and lower facets, the terminal facet prominently sunken. Sarcotesta light creamy yellow when ripe. Sclerotesta thin and papery, long ovoid, slightly flattened, 21–26 mm (0.8–1 in) long, 11–13 mm (0.4–0.5 in) in diameter, smooth. **Male cones** generally solitary but sometimes as many as three per crown, upright, 11–15 cm (4.3–6 in) long, 2.5–3.5 cm (1–1.4 in) in diameter, cream colored. Peduncle 2.5–3 cm (1–1.2 in) long, 10–12 mm (0.4–0.5 in) in diameter, densely red-brown tomentose. Sporophylls 7–10 mm (0.3–0.4 in) long. Sporophyll face 3–6 mm (to 0.2 in) high, 5–7 mm (0.2–0.3 in) wide, densely tan tomentose, the three upper and three lower facets distinct, the terminal facet slightly sunken and angled so that it faces in the direction of the cone apex. Sporangia in one patch covering the lower surface of the sporophyll, continuing up each side, leaving only a small central open space on the upper surface that may also occasionally contain sporangia. **Habitat:** Wet tropical rain forest on slopes of the continental divide at elevations of 925–1075 m (3000–3500 ft), only found as an epiphyte in the trees. The climate is characterized by almost continuous air movement because of the prevailing winds from the Caribbean. Clouds and fog keep the humidity high. **Distribution:** Panama, Atlantic (northern) slope of the Cordillera Central from at least central Bocas del Toro province, above Chiriquí Grande, from there east as far as Coclé province.

Zamia pseudoparasitica was described in 1854 by James Yates in Berthold Seemann's account of the voyage of H.M.S. *Herald.* Yates was considered one of the world's leading cycad experts and maintained one of the largest collections of living cycads in Europe. His description of *Z. pseudoparasitica* was based on material collected by the Polish botanist Józef Ritter von Rawicz Warszewicz in Panama, which had been sent to him by steamer from the Caribbean port of the Chagres River.

Zamia pseudoparasitica is without doubt one of the most remarkable cycads—it is the only truly epiphytic cycad. It is found only in trees and has never been reported growing in the ground. Plants dislodged from their high perches soon weaken and die on the ground below. This cycad has adapted to its aerial home by the formation of adventitious roots that hold it tightly to the tree, and long, pendent, flexible leaves that are well engineered to withstand winds prevailing in the canopy. It also has coralloid roots, containing cyanobacteria, that grow into hemispheric clusters 5–10 cm (2–3.9 in) in diameter, which no doubt produce much needed nutrients for the cycad in its treetop home.

There is no knowledge about the method of pollination or seed dispersal in *Zamia pseudoparasitica.* Insects probably play a major role in fertilization, but birds or mammals (possibly fruit bats) no doubt disperse the seed. Because of the extremely thin sclerotesta, I would guess that birds are the most likely dispersal agent. They could swallow the seed, later passing or regurgitating it entire, whereas a mammal with its sharp teeth would tend to puncture the thin sclerotesta. The sarcotesta of *Z. pseudoparasitica* has a very distinctive ripening process. In most zamias the sarcotesta is firm and usually of a somewhat dull coloration when seed is first shed. Within 1–3 days after seed is shed, the sarcotesta becomes soft and rubbery, and the color brightens. It is very difficult to remove the sarcotesta at this stage, even with a knife. Usually, bacterial decomposition occurs within a month, and the seed may then be easily cleaned. The sarcotesta of *Z. pseudoparasitica* is at first crisp when the seed is shed. It stays firm and creamy yellow about 2 weeks, then suddenly softens into a somewhat clear, sticky, jellylike consistency. At this time the seed is easily cleaned of its sarcotesta and is ready to germinate almost immediately. I have had seeds germinate while they were being soaked in water overnight to clean them thoroughly. This unusual ripening process may have some bearing on seed dispersal, and possibly on the animal dispersing it.

I have wondered just how the seed of *Zamia pseudoparasitica* might be grown in cultivation. No seedlings are found growing in the ground under the treetop colonies, and I felt that something special might be needed in the way of a planting medium. I was quite pleased to learn that in 1988 the staff of the Marie Selby Botanical Gardens, Sarasota, Florida, had successfully germinated and grown seed of *Z. pseudoparasitica.* They used an epiphyte mix both to germinate the seed and to grow the seedlings. At approximately 2 years of age the seedlings were very healthy and had five or six leaves. Plants that had been collected from the wild were not difficult to reestablish. They were placed in a hanging wire basket lined with sphagnum moss and filled with a light epiphyte mix such as that used for orchids or bromeliads.

Over its range, *Zamia pseudoparasitica* is relatively common, and many can be seen in the treetops. This aerial home protects them from almost anything but logging and road construction. Many have been lost through clearing for roads and habitations. In spite of this, *Z. pseudoparasitica* is not considered threatened, though the fragile balance could be easily upset at any time, and a constant vigil should be maintained to ensure that this unique cycad continues to flourish.

Zamia pumila Linnaeus 1763

PLATE 488

Zamia debilis [Linnaeus fil. in] Aiton 1789

Zamia latifoliolata Prenleloup 1872

Zamia allison-armourii Millspaugh 1900

Zamia pumila, the epithet derived from *pumilus,* Latin for dwarf or short, is called *guayiga,* the Spanish transliteration of the Taino Indian name. Chromosome number $2n = 16$. **Stems** subterranean, tuberous, 25–30 cm (10–12 in) long and 8–10 cm (3.2–4 in) in diameter, younger plants with a single crown, older plants generally dividing at the apex to form multiple crowns, the old leaf bases and cataphylls soon shed to form a smooth skin. Cataphylls long triangular, stipulate, slightly tomentose. **Leaves** usually four to eight, erect, dark green, 0.9–1.5 m (3–4.9 ft) long, 30–50 cm (12–20 in) wide, flat or slightly keeled, lightly and persistently tomentose. Petiole slightly flattened above, rounded below, brownish green, 20–40 cm (8–16 in) long, 5–7 mm (0.2–0.3 in) in diameter, unarmed. Leaflets in 25–31 pairs, dark green, flexible, moderately spaced, straight or slightly falcate, median leaflets 20–25 cm (8–10 in) long, 1.3–2 cm (0.5–0.8 in) wide, margin slightly revolute, armed with a few small teeth in the apical third, the teeth becoming more frequent toward the apex. **Female cones** solitary, erect, 10–15 cm (4–6 in) long, 6–8 cm (2.4–3.2 in) in diameter, densely red-brown to maroon tomentose, apex generally apiculate, composed of reduced sporophylls. Peduncle 25–40 mm (1–1.6 in) long, 13–15 mm (0.5–0.6 in) in diameter, densely red-brown tomentose. Sporophylls flattened, about 25 mm (1 in) long. Sporophyll face 12–15 mm (0.5–0.6 in) high, 28–32 mm (1.1–1.3 in) wide, the facets indistinct. Sarcotesta red when ripe. Sclerotesta irregularly globose to short ovoid, somewhat three-sided, 16–20 mm (0.6–0.8 in) long, 14–16 mm (0.6 in) in diameter, smooth except for four or five short, indistinct longitudinal grooves radiating from the chalaza. **Male cones** one to several, long conical, erect until the pollen is shed, 8–13 cm (3.2–5.1 in) long, 20–24 mm (0.8–0.9 in) in diameter, densely red-brown to light brown tomentose, apex blunt, composed of reduced sporophylls. Peduncle 1–2 cm (0.4–0.8 in) long, 7–10 mm (0.3–0.4 in) in diameter, densely brown tomentose. Sporophylls 5–8 mm (0.2–0.3 in) long, densely red-brown tomentose. Sporophyll face 4–5 mm (0.2 in) high, 12–17 mm (0.5–0.7 in) wide, the facets indistinct. Sporangia in two patches. **Habitat:** Subtropical dry forest in both open and understory situations, the soil generally clay over limestone, occasionally pure sand in beach areas, from sea level to 460 m (1500 ft). Rainfall averages 1500 mm (59 in) annually, evenly distributed throughout the year. The annual temperature ranges from highs of about 35°C (95°F) to lows of about 10°C (50°F). **Distribution:** Dominican Republic, mainly the southern and eastern coastal areas with very few colonies inland or to the north, from Baní, Peravia province, eastward to Cabo Engaño, Altagracia province, also on the islands of Catalina and Saona.

Zamia pumila is the type species of the genus and was described by Carl Linnaeus when he established the genus in the second edition of *Species Plantarum* in 1763. It is the only species of *Zamia* found on the island of Hispaniola. The original inhabitants of Hispaniola used this *Zamia,* which they called *guayiga,* as an item of food. In 1516 the Spanish missionary and historian Bartolomé de Las Casas reported that the Taino Indians made a sort of bread out of these zamias. The tubers were grated until they were made into rough dough, which was then formed into a ball and placed in the sun. The dough ball, said to be the color of sawdust, was left in the sun 2–3 days, at which time it had turned blackish and was swarming with grubs. Then the dough was made into tortillas that were cooked over a fire until somewhat stiff. During cooking, the grubs were killed and the tortilla was rich in starch from the *Zamia* and protein from the grubs. Eating the bread before it had grubs was said to be dangerous as it was still very poisonous. This form of *Zamia* preparation is said to have disappeared with the last of the Taino Indians.

In more recent times, *Zamia pumila* has been an item of commerce, and many thousands have been dug up and exported for use as ornamental plants. *Zamia pumila* is considered a weed in some areas of the Dominican Republic because of its rapid growth and the large numbers encountered in its habitat.

In cultivation, *Zamia pumila* makes a fine pot plant for indoor use, or it can be used as a landscape plant in areas with climatic conditions acceptable to it. The growth of this cycad is rapid, and if both males and females are grown, hand pollination can be effective in producing viable seed. Coning plants can be grown from seed in 3–5 years. As the plants age, their apex will split from time to time to form multiple crowns, each one producing leaves and cones. *Zamia pumila* is a handsome plant that will do equally well in low light and full sun.

In spite of the thousands of plants that have been exported in more recent years, the conservation status of *Zamia pumila* is still considered as safe. The great numbers of this cycad in the wild and its rapid regeneration in habitat seem to be enough to ensure its continued survival.

Zamia purpurea Vovides, J. D. Rees & Vázquez-Torres 1983

PLATE 489

The epithet for *Zamia purpurea* is derived from *purpureus,* Latin for purple and referring to the brown-purple newly emerging leaves. Chromosome number $2n = 16$. **Stems** subterranean, tuberous, 20–25 cm (8–10 in) long, 4–5 cm (1.6–2 in) in diameter, smooth skinned, and gray. Cataphylls broadly or narrowly triangular, tomentose, deciduous, 3.5–4 cm (1.4–1.6 in) long. **Leaves** usually one or two, rarely more, pale green, 10–83 cm (4–33 in) long, 15–45 cm (6–18 in) wide, flat to slightly keeled, emergent leaves glossy purplish brown, slightly tomentose. Petiole terete, 10–50 cm (4–20 in) long, 4–6 mm (0.2 in) in diameter, armed with a few scattered spines. Leaflets in three or four pairs, immature leaflets brown-purple, adult leaflets pale green, glossy, glabrous, 6–26.5 cm (2.4–10 in) long, 2–8 cm (0.8–3.2 in) wide, elliptical, opposite or alternate, the veins sometimes slightly elevated on the upper and lower surfaces, margin slightly revolute, serrate in the apical half to two-thirds of the leaflet. **Female cones** solitary, erect, conical, 6.5–8.5 cm (2.6–3.3 in) long, 3.5–4.5 cm (1.4–1.8 in) in diameter, dark purple-brown. Peduncle 20–25 mm (0.8–1 in) long, 12–14 mm (0.5–0.6 in) in diameter, tomentose. Sporophyll face rounded, somewhat hexagonal, 13–15 mm (0.5–0.6 in) high, 20–25 mm (0.8–1 in) wide, the facets indistinct. Sarcotesta rose to red when ripe. Sclerotesta irregularly ovoid, 13–17 mm (0.5–0.7 in) long, 7–12 mm (0.3–0.5 in) in diameter, smooth, with three to five shallow longitudinal grooves. **Male cones** usually one or two, rarely more, conical, 2.5–3 cm (1–1.2 in) long, 8–10 mm (0.3–0.4 in) in diameter, brown. Peduncle brown tomentose, 1–2.5 cm (0.4–1 in) long, 4–6 mm (0.2 in) in diameter. Sporophylls 2–3 mm long. Sporophyll face 2–3 mm high, 2–4 mm wide. Sporangia on the sides of the sporophyll, with usually only one to three on each side. **Habitat:** Mainly, evergreen or nearly evergreen rain forest as an understory plant, generally in limestone outcrops and on rain forest floor, at elevations of 100–150 m (330–490 ft). Rainfall is 1500–2000 mm (59–79 in) annually, falling mostly in summer. The climate is generally hot and humid with temperatures of 20–30°C (68–86°F) in summer, above 20°C (68°F) in winter. **Distribution:** Mexico, southern portions of Veracruz and Oaxaca states in the Uxpanapa district.

Zamia purpurea was discovered by John D. Rees in 1978 while he was investigating the newly opened Uxpanapa region in southern Oaxaca, Mexico. He immediately recognized it as an undescribed species of *Zamia* and collected specimens for study. Rees and two other botanists, Andrew P. Vovides and Mario Vázquez-Torres, described *Z. purpurea* as a new species in the *Flora de Veracruz* in 1983.

Zamia purpurea is one of the most interesting and beautiful of the Mexican zamias. Its small size, distinctive leaf color, and very glossy leaflets combine to produce an outstanding appearance. The purple-brown color of the emerging leaves will persist for a year or more, adding to the beauty and interest of this cycad. Remarkable also are the very small cones of *Z. purpurea,* which are also distinctively purple-brown.

In the 1990s an undescribed zamia, closely related to *Zamia purpurea,* was discovered some miles north of the *Z. purpurea* habitat. This taxon has purple emergent leaves like those of *Z. purpurea* but the leaflet surface is dull rather than glossy, and its veins are markedly elevated above the leaflet surface. In its way, this zamia is just as beautiful as *Z. purpurea.* Additional fieldwork will be necessary to ascertain if these two taxa intergrade or if they are completely isolated from each other.

Zamia purpurea is not common in its habitat, which has unfortunately been drastically reduced through land clearance for agriculture and cattle grazing. *Zamia purpurea* has never been collected commercially, and to my knowledge there are very few plants of this species in cultivation. This is mainly the result of its remote habitat and the fact that in no place has it been found to be common. Because of the beauty and desirability of *Z. purpurea,* it is a prime candidate for artificial propagation.

The conservation status of *Zamia purpurea* is difficult to determine as most of its habitat is not easily accessible. A great deal of its original habitat has been cleared for crops and grazing. On the other hand, it would seem from reports that its range is extensive and that many plants may still exist in the wild. Weighing all the facts, it would seem prudent to classify this species as endangered until additional data are available.

Zamia pygmaea Sims 1815

PLATES 490, 491

Zamia pumila subsp. *pygmaea* (Sims) Eckenwalder 1980
?*Zamia silicea* Britton 1916

Zamia pygmaea, the epithet derived from *pygmaeus,* Latin for pygmy or dwarf, referring to this cycad's small size, is called least zamia. Chromosome number 2*n* = 16. STEMS subterranean, tuberous, 10–15 cm (4–6 in) long, 3.5–4.5 cm (1.4–1.8 in) in diameter, younger plants with a single crown, older plants often dividing at the apex to form multiple crowns, the old leaf bases and cataphylls soon shed to form a smooth skin. Cataphylls long triangular, stipulate, densely tomentose. LEAVES usually one to three, spreading, medium green, 20–30 cm (8–12 in) long, 7–11 cm (2.8–4.3 in) wide, flat, lightly and persistently tomentose, seedling leaves usually with four leaflets. Petiole rounded, 8–15 cm (3.2–6 in) long, 2 mm in diameter, lightly and persistently tomentose, unarmed. Leaflets in 14–16 pairs, crowded, thin textured, median leaflets ovate to obovate, 4–6 cm (1.6–2.4 in) long, 1–2 cm (0.4–0.8 in) wide, margin slightly revolute, with small teeth in the apical third to half of the leaflet. FEMALE CONES usually solitary, rarely two, ellipsoid, 5–8 cm (2–3.2 in) long, 3.5–5 cm (1.4–2 in) in diameter, densely dark brown to blackish brown tomentose, apex with a sterile cap. Peduncle 2–4 cm (0.8–1.6 in) long, 1 cm (0.4 in) in diameter. Sporophyll face indistinctly hexagonal, 12–15 mm (0.5–0.6 in) high, 20–23 mm (0.8–0.9 in) wide, the facets indistinct. Sarcotesta reddish orange when ripe. Sclerotesta smooth, 13–15 mm (0.5–0.6 in) long, 8–10 mm (0.3–0.4 in) in diameter. MALE CONES solitary to several, erect, cylindrical, 3–6 cm (1.2–2.4 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, densely red-brown tomentose, apex blunt, composed of reduced sporophylls. Peduncle 3–4 cm (1.2–1.6 in) long, 4–5 mm (0.2 in) in diameter, dark brown tomentose. Sporophyll face hexagonal, 5–7 mm (0.2–0.3 in) high and wide, the facets indistinct. Sporangia in two patches. HABITAT: Dry brush-covered hills, pinelands, and areas of white sand, from about sea level to 200 m (650 ft). Rainfall averages 1000–1500 mm (39–59 in) annually, falling mainly in summer. Temperatures are 20–30°C (68–86°F) all year. DISTRIBUTION: Cuba, Pinar del Río province in the western part of the island.

When *Zamia pygmaea* was described by John Sims in 1815, exact locality data were not given, nor were details of the female cone. *Zamia pygmaea,* as true of several other zamias described in the early nineteenth century, was not seen in habitat by its describer. The zamias were often known from a single herbarium sheet giving the collection area as "India Occidentalis" or "Antillae," that is, the West Indies. Later studies in the West Indies disclosed plants conforming to the description of *Z. pygmaea* growing in western Cuba. Lack of exact collection information has caused many problems through the years and will no doubt continue to do so.

The closest relative of *Zamia pygmaea* appears to be *Z. kickxii.* The distinctiveness of the latter species is somewhat questionable and several researchers have considered it a synonym of *Z. pygmaea.* There are a number of differences between *Z. pygmaea* and *Z. kickxii* in size and cones, leading me to treat them as separate species. No doubt, additional research will be necessary to resolve their classification. In addition, *Z. silicea* is an enigmatic cycad described from the Isle of Pines (now Isla de la Juventud) by Nathaniel Lord Britton in 1916. It has generally been placed in synonymy under *Z. pygmaea,* but photographs show a plant with stiff leaves, curved backward and downward, strongly keeled, quite different from *Z. pygmaea.* Here again is a case where modern fieldwork will be necessary to clarify the proper position of this taxon in the genus.

In cultivation, *Zamia pygmaea* is a rewarding and handsome little cycad. Its small size makes it a fine pot plant, or useful in garden borders. The sole problem with *Z. pygmaea* is its lack of availability. There are probably no more than a hundred plants of this species in cultivation in the United States. Some artificial propagation is now being accomplished and it is hoped that *Z. pygmaea* will not be so rare in the future. The cycad grows rapidly from seed, and I have been able to grow coning plants from seed in 2 years. *Zamia pygmaea* is undemanding, easily adjusting to most garden situations. It does best in a sunny location with well-drained soil and occasional applications of fertilizer. It is quite cold tolerant and will withstand several degrees of frost without apparent damage. When grown outdoors in temperate climates, it is best to cover the tuber with soil to protect it from the occasional freezes that occur from time to time. The main insect pests affecting *Z. pygmaea* are scale insects and mealybugs. Infestations of these insects must be dealt with at once to prevent leaf loss or crown damage.

The conservation status of *Zamia pygmaea* is not adequately known. Travel to Cuba has become somewhat easier, with some botanical exploration recommenced in 1994. Two trips into Pinar del Río in western Cuba resulted in the discovery of a limited number of *Z. pygmaea* plants. Because of the small number of plants observed, this species must be considered endangered until such time as additional data are available.

Zamia roezlii Linden 1873

PLATES 492, 493

Aulacophyllum roezlii (Linden) Regel 1876a

Zamia roezlii, named in honor of Benedikt Roezl (1824–1885), this cycad's discoverer, is called *chigua* by Indians in Colombia. Chromosome numbers $2n = 22, 24–26$. **Stems** arborescent, erect and generally 2–3 m (6.5–10 ft) tall or decumbent and 2–6.5 m (7–21 ft) long in very old specimens, 15–30 cm (6–12 in) in diameter, often covered with epiphytic plants. **Leaves** usually 10–16, sometimes as many as 45, erect to spreading, glossy green, 2.5–3 m (8.2–10 ft) long, 61–76 cm (24–30 in) wide, flat, emergent leaves glabrous and light reddish brown. Petiole terete, slightly flattened above, 62.5–87.5 cm (25–35 in) long, 12–15 mm (0.5–0.6 in) in diameter, heavily armed with spines 2–3 mm long that continue onto the rachis, the expanded base covered with a persistent brown tomentum. Leaflets in 12–27 pairs, lanceolate, often falcate, the veins depressed above and elevated below for a corrugated effect, glossy, dark green above and lighter green below, median leaflets 36–40 cm (14–16 in) long, 2.5–3.5 cm (1–1.4 in) wide, margin entire and strongly revolute. **Female cones** solitary, cylindrical, 15–20 cm (6–8 in) in diameter somewhat pendent when mature, 27.5–55 cm (11–22 in) long, 10–14 cm (4–5.5 in) in diameter, densely rust brown tomentose, apex an apiculate sterile cap. Peduncle 8–12 cm (3.2–4.7 in) long, 2 cm (0.8 in) in diameter, densely brown tomentose. Sporophylls 3.5–4 cm (1.4–1.6 in) long. Sporophyll face hexagonal, 15–18 mm (0.6–0.7 in) high, 30–35 mm (1.2–1.4 in) wide, with distinct upper and lower facets, the terminal facet sunken. Sarcotesta bright orange-red when ripe. Sclerotesta somewhat cylindrical, 20–32 mm (0.8–1.3 in) long, 10–13 mm (0.4–0.5 in) in diameter, smooth. **Male cones** usually one to five, erect, 17–20 cm (6.7–8 in) long, 3.5–4 cm (1.4–1.6 in) in diameter, densely rust brown to tan tomentose, the terminal facets usually somewhat darker. Peduncle 15–20 cm (6–8 in) long, 1–1.5 cm (0.4–0.6 in) in diameter, densely cinnamon brown tomentose. Sporophylls 10–18 mm (0.4–0.7 in) long. Sporophyll face hexagonal, 2–3 mm high, 3–4 mm wide, projecting 3–4 mm, the terminal facet sunken and darker. Sporangia in one patch covering the lower surface and sides of the sporophyll. **Habitat:** Always near the seashore or on low islands in coastal areas and at the mouths of rivers, often just above the mangrove line and inundated by sea water at the highest tides. **Distribution:** Colombia, Valle del Cauca and Chocó departments, from just north of Buenaventura at the mouth of the Río San Juan, possibly to as far north as Darién province, Panama, with unconfirmed reports from extreme northern coastal Ecuador.

In 1845–1851, Berthold Seemann held the position of naturalist aboard the vessel H.M.S. *Herald.* The voyage of the *Herald* was a scientific expedition whose main goal was to locate either survivors or the remains of a polar expedition led by Sir John Franklin. The route of the *Herald* was up the western coast of the Americas, terminating in the Bering Sea, where it was presumed that Franklin's expedition had disappeared. During the voyage, Seemann had many opportunities to go ashore and collect specimens, including *Z. chigua,* which he described in 1852 and said was collected at the mouth of the Río San Juan in Colombia. In the 1970s, plants thought to be *Z. chigua* were collected at the same location and brought into cultivation in the United States. As the location was the same as that given by Seemann for *Z. chigua,* and the local Indians called the plant *chigua,* they were accepted as *Z. chigua* and labeled as such. It was not until some years later that Robert L. Dressler compared Seemann's illustration of *Z. chigua* with the plants collected at the mouth of the Río San Juan, which did not match, and a mix-up was discovered. Seemann must have mistakenly applied the collection data for *Z. chigua* to what was later described as *Z. roezlii.* The confusion was brought about by Seemann's statement that *Z. chigua* was collected at the mouth of the Río San Juan, when in fact the only cycad occurring there is *Z. roezlii. Zamia chigua* is found farther inland.

Chromosome counts of *Zamia roezlii* are remarkable as they have been found to vary, $2n = 22, 24, 25$, and 26. It is generally accepted that this variation indicates that *Z. roezlii* is one of the most primitive zamias.

Zamia roezlii is one of the largest and most majestic of the species of the genus. At a distance, this cycad is easily mistaken for a palm, which it resembles in both size and habit. The habitat of this cycad is usually in close proximity to the seashore, with many of the plants growing in swamps along the coastline just above the mangrove belt. The bases of zamias growing in such swampy areas are subjected to inundation by brackish water during the highest tides and must therefore be quite salt tolerant. The largest specimens, too heavy to be supported by their roots in the soft muck, often fall over and can be found decumbent, rooting adventitiously along their stems. These ancient plants continue growing, the crown once again becoming erect and luxuriant.

The local Indians use the seed of *Zamia roezlii* as food and consider it a delicacy. A kind of flour is made from the endosperm after it has been ground, soaked and washed to remove the toxic substances, then dried. Sometimes, cones can be seen by the Indian huts, waiting to be processed.

Zamia roezlii is easy to grow and is an exceptional plant for the collector who lives in a tropical climate or who has a larger greenhouse. The large stems, long leaves, and glossy leaflets with their corrugated surface combine to make this cycad one of the most handsome of the zamias. It looks best when given some protection from the sun and will not adjust to heavy soil in cultivation as it does in habitat. *Zamia roezlii* is best kept in the background of a landscape setting because of its large size and extremely spiny petioles. Growing the species from seed can at times be frustrating as there is usually a considerable loss of seedlings through damping-off. Collecting seed before it is completely ripe may be the cause. Because of this fungal problem, great care must be taken at the early seedling stage to keep plants from staying too wet.

The conservation status of *Zamia roezlii* seems quite secure. The species has a large range over generally poor land with few human inhabitants. Regeneration is not prolific, and young plants are scarce in the wild. Plants grow to a great size and age, however, so the sporadic regeneration should be sufficient to maintain the wild populations. The Indians' practice of collecting seed of this cycad for consumption could in time cause a decline in the numbers of this species, but for the present, at least, *Z. roezlii* does not appear to be threatened.

Zamia skinneri Warszewicz ex Dietrich 1851

PLATE 494

Aulacophyllum skinneri (Warszewicz ex Dietrich) Regel 1876a

Zamia skinneri is named in honor of George Ure Skinner (1804–1867), English amateur botanist and plant collector in Central and South America. Chromosome numbers $2n = 18, 22$. **Stems** arborescent, erect, 1–2.5 m (3.3–8.2 ft) long or more, 8–15 cm (3.2–6 in) in diameter, leaf bases not persistent and the stem surface becoming more or less smooth and skinlike. **Leaves** usually three to six in mature plants, erect to spreading, arching, bright to dark green, 1–2 m (3.3–6.6 ft) long, 0.6–1.1 m (2–3.6 ft) wide, flat, emergent leaves glabrous, either bright green or reddish brown. Petiole olive green, 0.5–1 m (1.6–3.3 ft) long, 1–1.3 cm (0.4–0.5 in) in diameter, sparsely to densely armed, base swollen and tomentose. Leaflets in two to seven pairs, leathery, broadly lanceolate, glossy green above, lighter below, veins depressed above, giving a corrugated appearance, prominently raised below, median leaflets 31–56 cm (12–22 in) long, 8–20 cm (3.2–8 in) wide, margin revolute, toothed or with small teeth in the upper half to two-thirds of the leaflet. **Female cones** solitary, cylindrical to ovoid cylindrical, 20–40 cm (8–16 in) long, 8–12 cm (3.2–4.7 in) in diameter, densely red-brown tomentose, apex a blunt sterile cap. Peduncle 20–70 mm (0.8–2.8 in) long, stout, 38 mm (1.5 in) in diameter, densely yellow-brown tomentose. Sporophylls rhomboid, 10 mm (0.4 in) high, 16–20 mm (0.6–0.8 in) wide, the facets distinct. Sarcotesta red-orange when ripe. Sclerotesta somewhat three-sided, long ovoid, 21–26 mm (0.8–1 in) long, 11–13 mm (0.4–0.5 in) in diameter, smooth. Chalaza 2 mm in diameter, composed of three shallow pits. **Male cones** usually one to four (or more?), erect, arising in succession, elongate cylindrical, 4–15 cm (1.6–5.9 in) long, 1–2.5 cm (0.4–1 in) in diameter, densely red-brown tomentose, apex a sterile cap composed of reduced sporophylls. Peduncle 2–12 cm (0.8–4.7 in) long, 9–12 mm (0.4–0.5 in) in diameter. Sporophylls about 8 mm (0.3 in) long. Sporophyll face densely brown tomentose, 3–4 mm high, 5–6 mm (0.2 in) wide, projecting about 3 mm, the terminal facet distinctly sunken. Sporangia in two small patches confined to the sides and underside of the sporophyll. **Habitat:** Wet tropical rain forest at elevations of 200–500 m (660–1600 ft). Rainfall averages 4000–6000 mm (160–240 in) annually, falling all year but with the heaviest precipitation April–December. Temperatures generally average 25–27°C (77–81°F) throughout the year. **Distribution:** Panama, Caribbean (northern) coast, reported from Bocas del Toro, Coclé, and Darién (?) provinces, and the Canal Zone. Costa Rica (?).

Józef Ritter von Rawicz Warszewicz, a Polish botanist, originally collected *Zamia skinneri* while exploring the mountainous regions of the Isthmus of Panama. Its discovery was said to be made early in 1850, and the German botanist Albert Gottfried Dietrich described the species in 1851 using Warszewicz's collections and observations. Shortly thereafter, Berthold Seemann also found plants of the same species but mistakenly recorded the locality as Cabo Corrientes, Colombia.

It is indeed strange that a cycad as remarkable as *Zamia skinneri,* discovered well more than a century ago, is still so incompletely known. Plants similar to Warszewicz's original discovery have been found near El Copé, Panama, but a smaller plant from near the Fortuna Valley may represent another species though it closely resembles *Z. skinneri.* It is interesting to note that the El Copé plants have longer leaves and leaflets and are always red emergent whereas the smaller Fortuna Valley plants always have green emergent leaves. There are also at least two localities in Costa Rica, Lake Arenal and BriBri, where *Z. skinneri* (?) has been reported. I have studied cultivated specimens from both populations and the character of their leaflets is very distinctive. Leaflets of the Lake Arenal plants are broadly linear lanceolate and slightly falcate, those of the BriBri plants broaden toward the apex, with the widest part just before the abruptly acuminate apex. When cones become available, these plants may prove to be closely related to, but distinct from, *Z. skinneri.* What is sorely needed are more collections of living material and herbarium specimens so that the limits of distribution and the range of variability of *Z. skinneri* and its close relatives can be documented. (See also the remarks about *Z. skinneri* in the discussion of *Z. neurophyllidia.*)

Zamia skinneri in Panama is said to be found sometimes as solitary specimens, other times in dense colonies. My limited experience in Panama agrees with the former observation. The species was never common in the areas I surveyed, and that did not seem to be the result of collectors or clearing of the habitat.

Zamia skinneri is not often found in collections but that does not seem to be the result of difficulty in cultivation. In my experience, *Z. skinneri* has been easy to grow and cone. It is a rewarding plant because of its beauty and its unusually large leaflets. It does demand warm, humid, shady conditions similar to those in its habitat, so greenhouse culture is necessary in all but the most tropical climates.

Information is insufficient to assess the conservation status of *Zamia skinneri.* The Costa Rican plants are probably not this species. The remaining locations in Panama lead me to believe that this cycad should be considered endangered. It is hoped that something can be done to preserve some of its habitat from the continuing destruction of the rain forest.

Zamia soconuscensis Schutzman, Vovides & Dehgan 1988

PLATE 495

The epithet for *Zamia soconuscensis* refers to the Sierra del Soconusco, also known as the Sierra Madre de Chiapas, where this cycad is native. Chromosome number $2n$ = 16. **Stems** arborescent, erect when small but leaning or decumbent with age and greater size, 1–1.5 m (3.3–4.9 ft) long, 5–25 cm (2–9.8 in) in diameter, infrequently branched and then usually as the result of injury. Cataphylls elongate triangular, stipulate, tomentose, about 4.5 cm (1.8 in) long, 1.5 cm (0.6 in) wide. **Leaves** usually 15–70 depending on size and condition of the plant, spreading, arching, 0.4–1.9 m (1.3–6.2 ft) long, 25–64 cm (10–25 in) wide, flat, emergent leaves white tomentose, then glabrous and green at maturity. Petiole 14–28 cm (5.5–11 in) long, 4–10 mm (to 0.4 in) in diameter, lightly armed, especially so toward the petiole base, the spines 0.5–4 mm long, base massive and spineless. Leaflets long lanceolate, falcate to subfalcate, held more or less at right angles to the rachis except at the apex where they are angled forward, median leaflets 14–33 cm (5.5–13 in) long, 6–14 mm (0.2–0.6 in) wide, margin entire and subrevolute. **Female cones** solitary, erect, cylindrical, barrel shaped, 12–21 cm (4.7–8.3 in) long, 7–10 cm (2.8–4 in) in diameter, dark brown tomentose, apex mucronate. Peduncle 34–40 mm (1.3–1.6 in) long, 10–13 mm (0.4–0.5 in) in diameter. Sporophylls hexagonal truncate, 28–31 mm (1.1–1.2 in) long, with a short hexagonal truncate protuberance. Sporophyll face 18–24 mm (1.7–1 in) high, 32–48 mm (1.3–1.9 in) wide. Sarcotesta salmon pink when ripe. Sclerotesta 22–26 mm (0.9–1 in) long, 14–19 mm (0.6–0.7 in) in diameter, light tan, smooth, with six to eight shallow furrows running longitudinally and sometimes branching. **Male cones** usually one to five, cylindrical to conical, 9.5–10.5 cm (3.7–4.1 in) long, 15–21 mm (0.6–0.8 in) in diameter, dark brown tomentose. Peduncle 35–45 mm (1.4–1.8 in) long, 9–10 mm (0.4 in) in diameter, densely tomentose. Sporophyll face hexagonal truncate, 3–4 mm high, 4–5 mm (0.2 in) wide. Sporangia in two patches on the sides of the sporophyll, nearly spherical, 16–24 per sporophyll. **Habitat:** Understory in primary rain forest in very organic clay soils, at elevations of 1035–1400 m (3400–4600 ft). Rainfall is generally more than 2000 mm (79 in) annually, falling mainly in summer. Temperatures range from highs in excess of 30°C (86°F) to lows of 15°C (59°F). **Distribution:** Mexico, Chiapas state, Sierra Madre de Chiapas (Sierra de Soconusco), occurring as scattered localized colonies and probably narrowly endemic.

What would be described as *Zamia soconuscensis* was discovered in 1938 by Eizi Matuda while he was making a comprehensive study of the Soconusco district of Chiapas, Mexico. At first he confused it with *Ceratozamia matudae,* which occurs in the same area and is superficially similar in leaf and leaflet characteristics. Later, when Matuda realized these particular plants were in fact zamias, he tentatively identified them as *Z. loddigesii,* but *Z. soconuscensis* is a truly arborescent *Zamia* with stems to 1 m (3.3 ft) or more high.

There are a number of arborescent zamias found from Guatemala south into South America, usually growing in areas of high rainfall and in a tropical climate. Their stems are covered with a thin epidermis, not the armor of persistent leaf bases found on most arborescent cycads such as *Ceratozamia, Cycas, Dioon,* and *Encephalartos,* and more tropical conditions are necessary to protect them from desiccation. The only other Mexican species of *Zamia* that are considered arborescent are *Z. furfuracea* and *Z. inermis.* Those species, however, seldom have stems that extend more than 15–25 cm (6–10 in) above the soil line.

Zamia soconuscensis is a more recent addition to the cultivated species of the genus, therefore not much is known about its long-term response to cultivation. Judging by what information is available, it would seem that it presents no major problems in cultivation. It demands good drainage and a tropical or subtropical climate. Seedlings I have grown under greenhouse conditions have done quite well, and their growth rate is rapid. *Zamia soconuscensis,* with its long, arching leaves and numerous fine leaflets, is a very decorative cycad, and it is hoped that seeds or seedlings will become more readily available. *Zamia soconuscensis* is considered endangered, chiefly because of clearing of its habitat for corn and coffee production, and lumbering.

Zamia spartea A. de Candolle 1868

PLATE 496

Zamia loddigesii var. *spartea* (A. de Candolle) J. Schuster 1932

The epithet for *Zamia spartea* is Latin and means resembling grass, referring to the long, narrow leaflets that are difficult to distinguish from grass. Chromosome number $2n = 18$. **Stems** subterranean, tuberous, rarely branched, 12–30 cm (4.7–12 in) long, 4–6 cm (1.6–2.4 in) in diameter. **Leaves** usually one to six, arching, glabrous, 60–75 cm (24–30 in) long, 50–60 cm (20–24 in) wide, flat to slightly keeled. Petiole terete, 20–35 cm (8–14 in) long, 5 mm (0.2 in) in diameter, lightly to heavily armed with spines 4–5 mm (0.2 in) long. Leaflets in 7–24 pairs, narrowly linear, gradually acuminate, the upper surface slightly to strongly concave, median leaflets 25–35 cm (10–14 in) long, 3–7 mm (to 0.3 in) wide, margins flat, with one to five teeth on both sides in the apical half. **Female cones** usually solitary, erect, ellipsoid, 4–6 cm (1.6–2.4 in) long, 4–5 cm (1.6–2 in) in diameter, yellowish gray, densely tomentose, sterile tip short and blunt. Peduncle 4–14 cm (1.6–5.5 in) long, 10–12 mm (0.4–0.5 in) in diameter, tomentose. Sporophylls 17–20 mm (0.7–0.8 in) long. Sporophyll face hexagonal, 8–10 mm (0.3–0.4 in) high, 8–15 mm (0.3–0.6 in) wide, densely gray-brown tomentose, tomentum darker at the center of the sporophyll. Sarcotesta orange-red when ripe. Sclerotesta ovoid, 11–13 mm (0.4–0.5 in) long, 8–9 mm (0.3–0.4 in) in diameter, light tan, smooth. **Male cones** usually solitary but sometimes two or more, upright, cylindrical, 6–9 cm (2.4–3.5 in) long, 15–23 mm (0.6–0.9 in) in diameter, densely light gray tomentose. Peduncle 5–10 cm (2–3.9 in) long, 8–10 mm (0.3–0.4 in) in diameter, densely gray tomentose. Sporophyll face 3–5 mm (to 0.2 in) high, 6–8 mm (0.2–0.3 in) wide. Sporangia in two groups on the underside of the sporophyll. **Habitat:** Dry oak forest at low elevations, occasionally hilly grassland. Rainfall averages 500–1000 mm (20–40 in) annually, falling mostly in summer. Temperatures range from summer highs of 33°C (91°F) to winter lows of 8°C (46°F). **Distribution:** Mexico, Oaxaca and Veracruz states, region of the Isthmus of Tehuantepec.

Alphonse de Candolle described *Zamia spartea* in 1868, choosing the name *spartea* because the leaves of this little cycad resemble grass. The name was well chosen as it is almost impossible to see this cycad where it grows among the various grasses in its habitat.

Zamia spartea is seldom seen in collections or gardens, probably because it was never sought by commercial collectors who seemed to prize more highly those species with broad leaflets. *Zamia spartea* is a worthy addition to any collection because of its small size and distinctive narrow leaflets. In cultivation, the cycad maintains many more leaves than it could in its dry habitat. One could almost describe it as lush when it is given sufficient fertilizer and water. In cultivation, growth is rapid, and coning will take place every year if the plant is grown properly. Under greenhouse conditions, seedlings will reach coning size in 4–5 years. The female cones are decorative and striking in appearance because of their long, upright peduncle, topped by an almost spherical cone. This dwarf cycad is a fine subject for growing in pots, and several can be grown together, making a fuller leaf display.

The conservation status of *Zamia spartea* appears good. It has suffered little of the habitat destruction so often seen in areas with more fertile soil. Most of this species' habitat is used for grazing cattle, which cause little damage to the zamias. Reproduction in habitat is good, and this cycad seems to have few natural enemies.

Zamia splendens Schutzman 1984

PLATE 497

The epithet for *Zamia splendens* is Latin for shining or brilliant, referring to the striking appearance of the leaf, which has an extremely glossy surface. Chromosome number $2n = 16$. STEMS subterranean, rarely branched, to 25 cm (10 in) long and 5 cm (2 in) in diameter but usually less, grayish. Cataphylls triangular, papery, irregularly twisted, 3–10 cm (1.2–3.9 in) long, eventually deciduous. LEAVES usually one or two per crown, upright and slightly arching, glossy dark green, 0.3–1 m (1–3.3 ft) long, 18–70 cm (7.1–28 in) wide, flat to slightly keeled, emergent leaves usually bright red-brown but some individuals with green emergent leaves. Petiole robust, 32.5–37.5 cm (13–15 in) long, 5–8 mm (0.2–0.3 in) in diameter, base flaring out at the attachment to the stem to 10–15 mm (0.4–0.6 in) wide, moderately to heavily armed with spines, mainly on the petiole but often extending onto the rachis. Leaflets in 4–10 pairs, very stiff and leathery, opposite to subopposite, glossy dark green above, dull below, flat, long elliptical, the veins visible but not elevated, median leaflets 27.5–30.5 cm (11–12 in) long, 30–65 mm (1.3–2.6 in) wide, margins serrulate in the apical two-thirds to four-fifths of the leaflet and slightly revolute. FEMALE CONES solitary, rarely two, subglobose to cylindrical, 7–13 cm (2.8–5.1 in) long, 4.5–6 cm (1.8–2.4 in) in diameter, at first light brown tomentose, later dark green and glabrescent, apex with a narrow conical projection. Peduncle decumbent and serpentine, 10–15 cm (4–6 in) long, 12–14 mm (0.5–0.6 in) in diameter, densely light brown tomentose. Sporophylls hexagonal, 20–22 mm (0.8–0.9 in) long, surface usually convex, smooth, but in some individuals with distinct terminal and lateral facets. Sporophyll face 12–19 mm (0.5–0.7 in) high, 25–35 mm (1–1.4 in) wide. Sarcotesta orange when ripe. Sclerotesta ovoid, somewhat three-sided, 16–19 mm (0.6–0.7 in) long, 10–11 mm (0.4 in) in diameter, smooth. MALE CONES two to seven or more per stem apex, long conical, 4–9 cm (1.6–3.5 in) long, 17–20 mm (0.7–0.8 in) in diameter, densely light brown tomentose. Peduncle 8–16 cm (3.2–6.3 in) long, 8–10 mm (0.3–0.4 in) in diameter, decumbent and serpentine, the cone held either horizontally or upright. Sporophyll face rounded, 4 mm high, 6–7 mm (0.2–0.3 in) wide, the facets indistinct. Sporangia in two groups restricted to the sides of the sporophyll. HABITAT: Rain forest in wet areas with low light levels at elevations of about 600 m (2000 ft), also reported to occur near Tuxtla Gutiérrez, Chiapas, at 1500 m (4900 ft). Rainfall averages 2000 mm (79 in) annually, falling mainly in summer. DISTRIBUTION: Mexico, Chiapas state, from near Ocozocoautla in the south, extending north possibly as far as Oaxaca, east to Tabasco state.

I first observed *Zamia splendens* in 1971 during an expedition to Chiapas, Mexico. Material that I later distributed was labeled *Zamia* "Mal Paso" in reference to its collection site on the road from Ocozocuautla, Chiapas, to the Mal Paso reservoir. Bart Schutzman, a botanist specializing in Mesoamerican cycads, described the species *Z. splendens* in 1984. Even in habitat *Z. splendens* is a strikingly beautiful plant. It grows in wet, low-light areas under a dense tree canopy in association with other shade-loving plants such as *Anthurium clarinervium* and *Chamaedorea.*

Zamia splendens, with its red emergent leaves and broad glossy leaflets, is one of the most beautiful species of the genus. In cultivation, *Z. splendens* grows to a much larger size than it does in the wild, and with proper care plants will produce several leaves more than 1 m (3.3 ft) tall. It is an undemanding cycad, relatively easy to grow. Sufficient shade is necessary for it to produce its broad glossy leaflets to their full beauty. *Zamia splendens* is reasonably frost tolerant and able to grow in warm temperate climates if given overhead protection, but it is best suited to subtropical and tropical climates.

The conservation status of *Zamia splendens* is apparently quite secure. The habitat of this cycad is suffering the same fate as so many others, slash-and-burn agriculture or land clearance for the planting of coffee. For a short period of time in the mid-1970s, *Z. splendens* was commercially collected and many hundreds were removed from habitat. An examination of this original collecting area in early 1990 disclosed that *Z. splendens* was still relatively common. Mature plants were in evidence and regeneration was at acceptable levels for a cycad population. These facts coupled with the large area of distribution would seem to indicate that *Z. splendens* not be considered threatened.

Zamia standleyi Schutzman 1989

PLATE 498

Zamia standleyi, named in honor of Paul Carpenter Standley (1884–1963), botanist and taxonomist well known for his work in Mexico and Central America, is called *comotillo* from the Spanish *comote,* tuber, and *yucca de raton,* referring to the cycad's use by the Indians as rat poison. Chromosome number $2n = 16$. STEMS subterranean, tuberous, sometimes multicrowned as a result of injury, to 36 cm (14 in) long and 8 cm (3.2 in) in diameter. Cataphylls papery, those formed before leaf production 35–50 mm (1.4–2 in) long, 14–26 mm (0.6–1 in) wide, triangular, stipulate, those formed before cone production 50–115 mm (2–4.5 in) long, 9–15 mm (0.4–0.6 in) wide, elongate triangular, without stipules but with a long, twisted, acuminate apex. LEAVES usually one to three depending on the size and condition of the plant, erect, arching, glossy dark green, 20–95 cm (8–37 in) long, 40–90 cm (16–36 in) wide, flat, emergent leaves densely white tomentose, soon glabrous, either red or bright green, the red leaves remaining bronze-red into maturity. Petiole more or less spiny, especially toward the petiole base, 10–55 cm (4–22 in) long, 3–6 mm (to 0.2 in) in diameter, base swollen, lacking spines and densely rusty tomentose. Leaflets long lanceolate, falcate, leathery, glossy green, with a distinctive medial fold, median leaflets 20–45 cm (8–18 in) long, 1.5–3.5 cm (0.6–1.4 in) wide, the margins slightly revolute, with fine serrations 1–5 mm (to 0.2 in) long, apex acute. FEMALE CONES solitary, erect, cylindrical, 8.5–11.5 cm (3.3–4.5 in) long, 4.3–8.5 cm (1.7–3.3 in) in diameter, densely cinnamon brown tomentose, with an extended apiculate apex. Peduncle 2.5–3.8 cm (1–1.5 in) long, 1.2–2.5 cm (0.5–1 in) in diameter, red-brown tomentose. Sporophylls wedge shaped, 1.6–1.9 cm (0.6–0.8 in) long. Sporophyll face hexagonal truncate, 8–11 mm (0.3–0.4 in) high, 18–20 mm (0.7–0.8 in) wide, flat, the facets distinct. Sarcotesta salmon pink, turning bright scarlet when ripe. Sclerotesta long ovoid, 15–18 mm (0.6–0.7 in) long, 8–11 mm (0.3–0.4 in) in diameter, smooth. MALE CONES one to four, decumbent, long conical, 7–8 cm (2.8–3.2 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, densely tan to dark brown tomentose, apex mucronate. Peduncle 2–4 cm (0.8–1.6 in) long, 6–10 mm (0.2–0.4 in) in diameter, brown tomentose. Sporophylls 7–8 mm (0.3 in) long. Sporophyll face hexagonal truncate, 3–4 mm high, 4–5 mm (0.2 in) wide, projecting about 2 mm, the facets distinct. Sporangia in two patches attached to the sides of the sporophyll, separated by a sterile zone about 2 mm wide. HABITAT: Seasonally dry woodlands and moist hillsides under the canopy of trees, from sea level to 100 m (330 ft), in sun only in cultivated fields where the cycads have survived land clearance. *Zamia standleyi* can be found growing with *Dioon mejiae* in the catchment of the Río Aguán. DISTRIBUTION: Honduras, northern river valleys in Atlántida, Yoro, Santa Bárbara, and Cortés departments, from San Pedro Sula eastward to the Río Platano, and believed to range into adjacent Nicaragua and Guatemala.

My first introduction to *Zamia standleyi* was in 1976 on a botanical expedition to Honduras to study *Dioon mejiae.* While searching for the dioons I found a single-leaved *Zamia* that was unfamiliar to me. It was a solitary plant that remained unique for several days. I questioned the local Indians about this plant and showed them the leaf I had collected. They immediately became very animated and told me that this was known as *comotillo* or *yucca de raton,* a very toxic plant that was used as a rat poison. It has also had some less beneficial uses as well. In 1937 Paul C. Standley wrote,

> In the coast of Honduras there is a species of this group (*Z. furfuracea* L.f.), which is known by the name Comotillo. Its root is very poisonous, and has been employed at times for criminal poisonings, as well as for poisoning noxious animals. There is a popular belief that the root, if out of the ground for two days, kills its human victim in two days; if dug in a week, it kills in a week, and so on.

These same Indians led me to a large colony of these zamias, which it seems do not often grow with the dioons that inhabit more or less the same general area at this locality. Relationships are recognized between *Zamia standleyi* and *Z. cremnophila, Z. loddigesii,* and *Z. splendens* rather than *Z. furfuracea.* The only one that might be mistaken for *Z. standleyi* is *Z. loddigesii.* The two can be easily distinguished by noting that leaflets of *Z. standleyi* are falcate with a central fold whereas those of *Z. loddigesii* are not.

Zamia standleyi grows quite well in tropical and subtropical climates but is marginal in temperate areas. This *Zamia* is fine as a collector's item but does not hold enough leaves (unless planted in groups) to make it useful as a container or landscape plant. Even in cultivation, two to four leaves may be considered the maximum. There is a possibility that plants grown from seed may produce more leaves but that will have to be tested. In its habitat, I have never seen a specimen with more than two. Some of these leaves can be quite large, slightly less than 1 m (3.3 ft) long. The upright growth habit, arching leaf apex, and falcate leaflets combine to produce a striking cycad.

I have had no problems raising *Zamia standleyi* from seed, but a South African correspondent wrote, "*Z. standleyi*: I cannot keep this alive and have lost interest." In my experience it has proved to be reliable and moderately fast growing, with few problems in cultivation. Once mature, the plants cone yearly and seed is easily set. The cones take about a year to mature, and once the seed has been shed another 6–8 months is necessary for the embryo to develop. This *Zamia* can withstand several degrees of frost for short periods of time, though leaf damage will usually occur. When grown outdoors in frost-prone areas, the tuber should always be completely buried in the ground to protect it.

The conservation status of *Zamia standleyi* apparently is very secure. *Zamia standleyi* has been reported over a wide range in Honduras, from near the border with Guatemala in the west, as far east as the Río Platano. Generally, the plants are either widely scattered or found in colonies composed of numerous individuals. Most of its habitat is not easily converted into farmland, which has been beneficial to the cycad's survival. Other than as a poison, it does not appear to be used in any way. At least for the present, *Z. standleyi* does not appear to be threatened.

Zamia tuerckheimii Donnell Smith 1903

PLATES 499, 500

Zamia tuerckheimii is named in honor of Hans von Türckheim (1853–1920), German plant collector who managed a coffee plantation in Guatemala from about 1878 to 1908 and who is credited with the discovery of this cycad. Chromosome number $2n = 16$. **Stems** arborescent but immature specimens subterranean, older plants growing on cliffs often becoming pendent, then ascendant, forming a characteristic S shape, rarely branched, 1.5–3 m (4.9–10 ft) long, 8.8–20 cm (3.5–8 in) in diameter, with age the leaf bases and cataphylls shed, giving the stem a smooth skinlike appearance. **Leaves** usually 15–20, arching, glossy green, 1.4–1.8 m (4.6–5.9 ft) long, 20–45 cm (8–18 in) wide, flat, emergent leaves green with sparse white tomentum that is soon shed. Petiole more or less three-sided, 16.3–30 cm (6.4–12 in) long, 7–10 mm (0.3–0.4 in) in diameter, unarmed or sparsely armed with minute spines. Leaflets in 5–14 pairs, subopposite, oblanceolate, abruptly acuminate, gradually narrowed at the base, the upper surface glossy green, lower surface dull pale green, median leaflets 19–25 cm (7.5–10 in) long, 4–8 cm (1.6–3.2 in) wide, margin flat and entire. **Female cones** solitary, erect, then leaning, more or less cylindrical, 16.3–18.8 cm (6.5–7.5 in) long, 6–8.3 cm (2.4–3.3 in) in diameter, with a blunt or apiculate sterile apex. Peduncle 2–2.5 cm (0.8–1 in) long, 1.3–1.5 cm (0.5–0.6 in) in diameter, but the cone usually appearing sessile. Sporophylls hexagonal, 1.4–2 cm (0.6–0.8 in) high, 3.2–3.8 cm (1.3–1.5 in) wide, tomentose, flattened or sunken. Sarcotesta red-orange when ripe. Sclerotesta more or less three-sided, elongate ovoid, 2.2–2.5 cm (0.9–1 in) long, 1.3–1.5 cm (0.5–0.6 in) in diameter, medium brown, smooth. **Male cones** usually one to three, erect, narrowly cylindrical, 14–17 cm (5.5–7 in) long, 23–25 mm (0.9–1 in) in diameter, apex blunt and apiculate, composed of reduced sporophylls. Peduncle 5–6.5 cm (2–2.6 in) long, 5–8 mm (0.2–0.3 in) in diameter. Sporophylls truncate pyramidal, hexagonal, densely tan tomentose, the facets distinct, median sporophylls 8–10 mm (0.3–0.4 in) long, 3–4 mm high and wide. Sporangia in two patches on the lower side of the sporophyll. **Habitat:** Rain forest on and among limestone boulders at elevations of 300–1100 m (980–3600 ft). Rainfall averages 1500–2000 mm (59–79 in) annually, falling mainly in summer. Temperatures are 20–30°C (68–86°F) in summer, 10–20°C (50–68°F) in winter. **Distribution:** Guatemala, Alta Verapaz department, the type specimen collected at Cubilquitz but reported from Finca Volcán, Finca Seamay near Senahú, and on the Petén Highway between Campur and Secoyoucoch (Secouyou), also reported from Belize and Honduras but the collections may be assignable to other species.

The cycad that was to become known as *Zamia tuerckheimii* was discovered by Hans von Türckheim in July 1900 near Cubilquitz, Guatemala. Von Türckheim was a German who had settled in Guatemala in about 1878 to operate a coffee plantation. He was fascinated by plants and made many trips looking for new and interesting species. The *Zamia* that von Türckheim had collected near Cubilquitz was recognized as undescribed by John Donnell Smith, who described *Z. tuerckheimii* in 1903.

It is unusual that a cycad with the handsome appearance and ease of horticulture exhibited by *Zamia tuerckheimii* should be so seldom seen in collections. This scarcity cannot be attributed to difficulty of collection, nor rarity in habitat, for it grows in close proximity to good roads and is quite common within its range. The lack of plants in cultivation is probably because *Z. tuerckheimii* has not been overly exploited commercially, which is true in general for all the Guatemalan zamias.

Zamia tuerckheimii, unlike some of its relatives, produces numerous leaves at each growth cycle. The leaves are gently arching and lustrous green, and these features coupled with its luxuriant growth habit make it one of the most attractive zamias. Cold tolerance in *Z. tuerckheimii* seems somewhat better than in other tropical species of the genus, probably because of the relatively high elevation at which it grows. Several freezes in Florida produced minimal damage to plants grown outdoors but under cover of trees.

Viable seed of *Zamia tuerckheimii* has been produced in cultivation, and the resultant seedlings display a reasonably rapid growth rate. Male cones produce a great deal of pollen, and female cones are easily fertilized with it. An interesting fact is that female cones of *Z. tuerckheimii* take more than year, usually about 20 months, to mature fully. Most other species of *Zamia* need only 7–9 months. *Zamia tuerckheimii* is easy to grow and does not seem to pose any horticultural problems. Frequent applications of fertilizer maintain the good rate of growth and full complement of leaves. Although in its habitat *Z. tuerckheimii* grows under low-light conditions, when cultivated it seems to do better under a maximum of 50–60% shade. With brighter light, the coning frequency is far greater than it is in habitat.

The conservation status of *Zamia tuerckheimii* appears better than that of many zamias. It is still common over most of its range, and the rocky terrain it inhabits is not usable for crops of any kind. Regeneration is good, and the survival of this cycad, at least for the present, does not seem to be threatened.

Zamia ulei Dammer 1906

PLATE 501

Zamia ulei is named in honor of Ernst Heinrich Georg Ule (1854–1915), German botanist and plant collector who did extensive research in the Amazon and who first collected material of this cycad. Chromosome number $2n = 26$. Stems subterranean, tuberous, spindle shaped, generally unbranched, 12.5–30 cm (5–12 in) long, 4–8 cm (1.6–3.2 in) in diameter. Leaves usually one or two, glossy, bright green to yellow green, upright, 0.6–1.5 m (2–4.9 ft) long, 42–45 cm (16–18 in) wide. Petiole to 1 m (3.3 ft) long, terete, heavily armed with spines 1–4 mm long. Leaflets in five to eight pairs, ovate lanceolate, subfalcate, gradually acuminate, spaced 4–5 cm (1.6–2 in) apart, attachment at the base about 5 mm (0.2 in) wide, median leaflets 30–50 cm (12–20 in) long, 6–7.5 cm (2.4–3 in) wide, broadest near the leaflet apex and gradually narrowing toward the base, margins on both sides smooth except where armed with 12–15 small teeth near the leaflet apex. Female cones solitary, upright, 17–20 cm (6.7–8 in) long, 5–6 cm (2–2.4 in) in diameter, densely red-brown to brown tomentose, apex with a conical tip about 12 mm (0.5 in) long. Peduncle 4–5 cm (1.6–2 in) long, 1.5 cm (0.6 in) in diameter. Sporophylls hexagonal, flattened, dark red-brown tomentose, the facets distinct. Sporophyll face concave, 11–12 mm (0.4–0.5 in) high, 22–25 mm (0.9–1 in) wide. Sarcotesta red when ripe. Sclerotesta ovoid oblong, 12–15 mm (0.5–0.6 in) long, 8 mm (0.3 in) in diameter, nearly triangular in cross section, smooth. Male cones solitary to several, cylindrical, 6–10 cm (2.4–3.9 in) long, 1.5–2 cm (0.6–0.8 in) in diameter, red-brown tomentose. Peduncle 6–8 cm (2.4–3.2 in) long. Sporophylls in 12–16 vertical rows, strongly elevated at the sporophyll face. Habitat: Open tropical forest in very sandy soils at elevations of 100–200 m (330–650 ft). Rainfall averages about 2000 mm (79 in) annually, falling mainly in summer. Distribution: Brazil, western and central Amazonas state, near Cachoeira on the upper Juruá River. Peru, Boca de Moa near Leticia and Jurimaquas, Tarapoto and near St. Antonio, and Huallaga near Shapaga.

Not much is known of the small cycad, *Zamia ulei,* and little has been written about it. *Zamia ulei* seems to be one of the typical subterranean zamias that produce few leaves, and it inhabits a tropical environment.

Cultivation of *Zamia ulei* should not be different from any other species of *Zamia* from low-elevation rain forest. We may expect it to do best in heat and humidity sufficient to simulate its natural habitat. I have been successful growing it under greenhouse conditions for more than 4 years. Outdoor plantings should be confined to tropical and subtropical climates.

The conservation status of *Zamia ulei* is not known. Small colonies of scattered individuals have been reported as recently as 1996 but their extent and numbers are not known. The continued widespread destruction of the Peruvian and Brazilian rain forest, however, would lead us to believe that this species is threatened.

Zamia urep Wallnöfer 1996

According to Bruno Wallnöfer (pers. comm.), the epithet for *Zamia urep* has no meaning. It will be noted, however, that the name spelled backward is Peru. Chromosome number not known. Stems subterranean, tuberous, spindle shaped, about 10 cm (4 in) long, 2.5–3 cm (1–1.2 in) in diameter, the epidermis light brown. Cataphylls densely gray to light brown tomentose, 10–35 mm (0.4–1.4 in) long, 5–8 mm (0.2–0.3 in) wide at the base, gradually narrowed toward the apex. **Leaves** usually one or two, rarely four, erect, arched, 48–65 cm (19–26 in) long, 20–30 cm (8–12 in) wide. Petiole glabrous, greenish brown to light brown, 24–38 cm (9.4–15 in) long, rarely as long as 49 cm (19 in), completely unarmed. Leaflets generally in three or four pairs, leathery, opposite to subopposite, broadly lanceolate to elliptical, unequally acuminate toward the narrow apex, shiny dark green above, lighter green below, glabrous, with a petiolule 5–10 mm (0.2–0.4 in) long, median leaflets 11–20 cm (4.3–8 in) long, 3–6 cm (1.2–2.4 in) wide, broadest near the middle, with 19–23 veins that are prominently sunken above and elevated below, margins slightly revolute, entire in the lower third but sharply serrate in the apical two-thirds, with 8–19 teeth 0.5–1 mm long on either side. **Female cones** solitary, erect, barrel shaped, 3.5–4.7 cm (1.4–1.9 in) long, 2.3–2.5 cm (0.9–1 in) in diameter, densely light brown tomentose, with a sterile conical cap 7–10 mm (0.3–0.4 in) long, 5 mm (0.2 in) in diameter. Peduncle erect or slightly leaning, 13–16 cm (5.1–6.3 in) long, 3–5 mm (to 0.2 in) in diameter, generally rounded in cross section, brown, glabrous except for the apical 5–10 mm (0.2–0.4 in), which is densely tomentose. Sporophylls when immature hexagonal truncate, densely brown tomentose. Sporophyll face about 7 mm (0.3 in) high and 12 mm (0.5 in) wide, with a terminal facet displaying a distinct horizontal groove. **Male cones** solitary, rarely two, erect, cylindrical, 3.5–6 cm (1.4–2.4 in) long, 6–10 mm (0.2–0.4 in) in diameter, densely light brown tomentose, terminated by a sterile conical cap 4–5 mm (0.2 in) long. Peduncle erect to slightly leaning, 18–22 cm (7.1–8.7 in) long, 2–3 mm in diameter, glabrous except for the apical 1.5 cm (0.6 in) that is densely light brown tomentose. Sporophylls hexagonal truncate, the lateral facets steeply inclined and surrounding a flat to slightly depressed terminal facet, median sporophylls with face 1.8–2 mm high, 2–3.5 mm wide. **Habitat:** Primary montane rain forest on stony hillsides covered with a more or less thin layer of soil, at elevations of 260–700 m (850–2300 ft). **Distribution:** Peru, Huánuco administrative division, Pachitea province, on the western slope of the Sira Mountains about 20–24 km (12–15 miles) southeast of Puerto Inca.

Zamia urep is a more recently described species, specimens of which to my knowledge have not been mentioned previously in floras of Peru. I have seen neither dried nor fresh material of this species, making it difficult to determine its closest relatives. It is definitely part of the *Z. dressleri*–*Z. skinneri*–*Z. wallisii* complex because of its corrugated leaflets. Because of its completely subterranean stem, *Z. urep* would seem most closely related to *Z. dressleri. Zamia urep* may be separated from *Z. dressleri* by its smaller leaflets, 11–20 cm (4.3–8 in) long rather than 30–50 cm (12–20 in), and its petiolule, absent in *Z. dressleri.*

To my knowledge, there are no specimens of *Zamia urep* in cultivation. *Zamia urep* should respond to general greenhouse culture without difficulty. Its small size and decorative leaves will no doubt make *Z. urep* a popular species if living material is introduced into cultivation.

The conservation status of *Zamia urep* is apparently secure. Its habitat range is reasonably large, and it occurs frequently throughout the area. Although Bruno Wallnöfer made no mention of its reproduction in the wild, he stated that female cones were quite rare.

Zamia variegata Warszewicz 1845

PLATE 502

Zamia muricata var. *picta* Van Houtte 1846

Zamia muricata var. *picta* Miquel 1848, not Van Houtte 1846; *Z. picta* (Miquel) Thiselton-Dyer 1883b

The epithet for *Zamia variegata* is derived from *variegatus,* Latin for variegated, referring to the leaflets with their spots and flecks of color. Chromosome numbers $2n$ = 21, 22. **Stems** subterranean, tuberous, often forming more than one crown in older specimens, 20–25 cm (8–10 in) long, 7.5–10 cm (3–4 in) in diameter. Cataphylls long acuminate, stipulate, about 6.2 cm (2.4 in) long and 2.5 cm (1 in) wide at the base. **Leaves** usually one to three, upright, apex arching, 1–2.5 m (3.3–8.2 ft) long, 0.5–1 m (1.6–3.3 ft) wide, slightly keeled. Petiole subterete, 0.9–1.1 m (3–3.6 ft) long, 9–13 mm (0.4–0.5 in) in diameter just below the basal leaflets, armed with numerous short spines. Rachis in the area of the leaflets with two distinct grooves in the upper half, the leaflets attached within these grooves. Leaflets in 16–33 pairs, somewhat papery, dark green with spots and flecks of cream or yellow, individual plants may be lightly or densely variegated, median leaflets 30–52.5 cm (12–21 in) long, 3.8–9.4 cm (1.5–3.7 in) wide, in outline slightly curved forward, margin slightly revolute, serrate in the upper third to four-fifths, the serrations more numerous toward the apex. **Female cones** solitary, erect, 12.5–15 cm (5–6 in) long, 5–6 cm (2–2.4 in) in diameter, the surface gray-brown tomentose, apex blunt. Peduncle 5–6.3 cm (2–2.5 in) long, 1–1.3 cm (0.4–0.5 in) in diameter, tomentose. Sporophyll indistinctly rhomboid, 1.8–2 cm (0.7–0.8 in) long, densely gray-brown tomentose, with more or less indistinct facets, the terminal facet very slightly sunken. Sporophyll face 1.3–1.5 cm (0.5–0.6 in) high, 1.7–2 cm (0.7–0.8 in) wide. Sarcotesta red variegated with yellow when ripe. Sclerotesta somewhat three-sided, ovoid, 12–15 mm (0.5–0.6 in) long, 8–10 mm (0.3–0.4 in) in diameter, light tan, smooth. **Male cones** one to six, erect, long cylindrical, 8–10 cm (3.2–4 in) tall, 2–2.5 cm (0.8–1 in) in diameter, light tan tomentose, apex blunt, the cones subtended by two to four cataphylls about 7 cm (2.8 in) long. Peduncle 12–15 cm (4.7–6 in) long, 8–10 mm (0.3–0.4 in) in diameter, light brown tomentose. Sporophylls rounded, about 7 mm (0.3 in) long, light tan tomentose, with no distinct facets. Sporophyll face 4–5 mm (0.2 in) high, 6–8 mm (0.2–0.3 in) wide. Sporangia in two patches on the lower side of the sporophyll. **Habitat:** Wet lowland forest to higher elevation pine-oak forest, from sea level to 500 m (1600 ft). **Distribution:** Guatemala, catchment of the Río Motagua from about Gualán to Puerto Barrios on the Caribbean, perhaps also near the Mexican border in the vicinity of Sayaxché, Guatemala, reported circa 1992 from Chiapas state, Mexico, on the road from Bonampak to the Lagunas de Montebello, and also in coastal areas of Honduras and Belize.

In 1845 the Polish botanist Józef Ritter von Rawicz Warszewicz described *Zamia variegata* from plants he collected in Guatemala, without citing a locality. This was the first time a population of naturally variegated cycads had been described. The Belgian nurseryman, Louis Van Houtte, described *Z. muricata* var. *picta* in his *Catalogue* of 1846. Warszewicz stated in his description of *Z. variegata* that he had sent plants to Van Houtte in 1845. No doubt referring to the same *Zamia,* Friedrich Anton Wilhelm Miquel also described a *Z. muricata* var. *picta* in 1848, stating, “as many are identified as coming from Guatemala as from Mexico.” In 1883 William T. Thiselton-Dyer elevated Miquel’s variety to the rank of species, stating “It is remarkable that previous writers should have felt any hesitation in claiming for this splendid plant the specific rank which is undoubtedly due it. Its affinities with *Zamia muricata* are really comparatively remote.” He was of course referring to Van Houtte and Miquel, not Warszewicz.

In its habitat, *Zamia variegata* displays the typical subterranean tuberous stem of most zamias. *Zamia variegata* has few leaves, but they are remarkable for their length and variegated leaflets. As in most zamias, the overall length of leaf and length and width of leaflets are quite variable, depending on the amount of light the plant receives. The degree of variegation varies from plant to plant, some with leaflets almost totally dull green, others profusely variegated with small dots and dashes of yellow.

One of the most interesting features of *Zamia variegata,* and to my knowledge unique among the cycads, is the color of the seed sarcotesta. When seeds are first shed they are pinkish red, but when the sarcotesta is completely ripe and soft the color changes in some individuals to red variegated with yellow.

Without doubt, *Zamia variegata* ranks as one of the most distinctive cycads. There have been occasional reports of individual variegated cycads, but these are rare mutations seldom seen except in collections. In contrast, *Z. variegata* displays variegation to some extent in almost every plant. The chromosomes for variegation may be dominant, for this feature is apparent when *Z. variegata* is crossed with other compatible zamias. I am aware of two separate instances in which crosses between *Z. variegata* (female) and *Z. furfuracea* (male) produced offspring all with variegated leaves. These hybrids, though variegated, somewhat preserved the leaflet shape of *Z. variegata* and stiffer texture of *Z. furfuracea.* The leaves are more than 1 m (3.3 ft) tall, and the leaflets are broad lanceolate, 25 cm (10 in) long, 4 cm (1.6 in) wide, and dull green with yellow streaks and spots. The apical third of the leaflet is serrated with long teeth. All in all, it is a very handsome plant.

Horticulture of *Zamia variegata* is simple when plants are given sufficient heat and good drainage. *Zamia variegata* has little tolerance for frost and is best suited to tropical and subtropical climates. The growth rate is relatively fast, and a coning plant can be produced in less than 8 years from seed. The decorative variegated leaves make *Z. variegata* a must for any collection, either public or private.

The geographic range of *Zamia variegata* is large, if the total area covered is by only one species. There is a decided possibility that more than one taxon may be involved because of the disjunct areas of distribution in Mexico and Guatemala. This will require additional fieldwork to determine properly. The conservation status of *Z. variegata* seems to be secure, judging from the information at hand. Most collection data date back to the 1950s and 1960s, however, and many changes in its habitat must have taken place. On the positive side, two expeditions to Guatemala in 1996 showed *Z. variegata* as still locally common in some areas. Botanical exploration of Guatemala has been difficult because of political unrest, and it is hoped that this unique cycad will receive the attention it so justly deserves.

Zamia vazquezii D. W. Stevenson, Sabato & De Luca 1996

PLATES 503, 504

Zamia vazquezii is named in honor of Mario Vázquez-Torres, a researcher of Mexican and Central American cycads. Chromosome number $2n = 18$. STEMS subterranean, tuberous, 10–30 cm (4–12 in) long, 3–4 cm (1.2–1.6 in) in diameter, generally with a single crown but old plants often becoming multiheaded. LEAVES usually one to five, upright, light green, about 1 m (3.3 ft) long, 13.8–25 cm (5.4–10 in) wide. Petiole terete, stipulate, about 40 cm (16 in) long and 4 mm in diameter, unarmed or rarely with scattered small spines. Leaflets in 17–25 pairs, papery, abruptly and unevenly acuminate, somewhat wedge shaped, 7.5–12.5 cm (3–4.9 in) long, 2.5–3.8 cm (1–1.5 in) wide, margin slightly revolute, the apical two-thirds serrate. FEMALE CONES solitary, erect, 10–13.8 cm (4–5.4 in) long, 5–5.8 cm (2–2.3 in) in diameter, gray to gray-brown tomentose, apex blunt to narrow apiculate. Peduncle 2.5–3 cm (1–1.2 in) long, 6–7 mm (0.2–0.3 in) in diameter, gray tomentose. Sporophylls hexagonal. Sporophyll face 10–13 mm (0.4–0.5 in) high, 18–30 mm (0.7–1.2 in) wide, gray tomentose, with seven more or less distinct facets, the terminal facet transversely concave. Sarcotesta pinkish red when seed is first shed, orange when fully ripened. Sclerotesta more or less three-sided, subovoid, 13–15 mm (0.5–0.6 in) long, 10 mm (0.4 in) in diameter, smooth. MALE CONES one to three, erect until the pollen is shed, then leaning and soon dry, long conical, 7–11.5 cm (2.8–4.5 in) long, 1.2–2 cm (0.5–0.8 in) in diameter, densely gray tomentose. Peduncle 3.8–5 cm (1.5–2 in) long, 4–8 mm (to 0.3 in) in diameter, gray tomentose. Sporophylls wedge shaped, 5–7 mm (0.2–0.3 in) long. Sporophyll face hexagonal, 3–4 mm high, 7–10 mm (0.3–0.4 in) wide, more or less flat, the facets indistinct, the terminal facet slightly sunken. Sporangia in two patches on the lower edges of the sporophyll. HABITAT: Wet lowland forest in areas of deep shade, at elevations of about 600 m (2000 ft). Rainfall averages 1500–2000 mm (59–79 in) annually, falling mainly in summer. Temperatures are 10–20°C (50–68°F) in winter, 20–30°C (68–86°F) in summer. DISTRIBUTION: Mexico, in Hidalgo, San Luis Potosí, and Veracruz states along the Gulf of Mexico.

Zamia vazquezii is one of the most divergent species of the genus. Its papery, wedge-shaped or lanceolate leaflets, general lack of spines on the petiole, and fernlike growth habit set it apart from the majority. *Zamia vazquezii* is made up of three very distinctive forms, all three confined to the Gulf Coast of Mexico in Hidalgo, San Louis Potosí, and Veracruz. All three have female cones that remain densely gray tomentose. Two forms occur in San Luis Potosí and Hidalgo, one with light green, wedge-shaped leaflets, prominently serrate along the margin, the other with long, almost linear leaflets, deeply serrate (Plate 503). The third form is from Veracruz. Morphologically, it resembles the Hidalgo–San Louis Potosí form but is twice as large in every respect (Plate 504). It is very rare and restricted to northern Veracruz, where only a handful of specimens have been collected. It is the form on which the name *Z. vazquezii* is based. Study is hindered by the fact that the *Z. vazquezii* complex has been heavily collected over most of its range. It is now all but impossible to find the plants in many parts of their previously known areas of distribution. The large numbers of plants removed by commercial collectors, coupled with continual habitat destruction, has all but eradicated two of the three forms. Only the first San Louis Potosí form is still to be found in reasonable numbers in the wild. For many years *Z. vazquezii* was misidentified as *Z. fischeri* (as discussed in more detail under *Z. fischeri*).

All forms of the *Zamia vazquezii* complex grow exceedingly well in cultivation. They become so robust that clumps of more than a hundred crowns are not unusual, dwarfing the largest of their wild counterparts. Coning frequency also increases in cultivation, and large amounts of seed may be produced by anyone taking the time to hand pollinate them. Seedlings grow rapidly, and a coning plant may be produced in about 4 years. As houseplants, these cycads are unexcelled. Their small size, lack of spines, flexible leaves, and adaptability to low-light conditions make them some of the best cycads for indoor culture. As garden plants, they adapt to conditions of almost full sun to full shade if given sufficient moisture. Even though the leaves are papery and appear very tropical and fernlike, they can withstand several degrees of frost without damage.

The insect pests most frequently affecting the *Zamia vazquezii* complex are scale insects and mealybugs. Periodic treatment is suggested, especially during spring and summer, to control infestations. If these insects are allowed to go untreated, emergent leaves will be severely damaged or die, and in some cases the crown of the tuber may be killed.

The conservation status of *Zamia vazquezii* is clearly not good. Because of its beauty, the complex has been overcollected throughout most of its range. Habitat destruction has also contributed to declining numbers. There are very few areas where the cycads can still be found in large number, but these are the exception rather than the rule. For these reasons, *Z. vazquezii* must be considered endangered.

Zamia wallisii hort. Veitch ex A. Braun 1875

PLATE 505

Aulacophyllum wallisii (hort. Veitch ex A. Braun) Regel 1876a

Zamia wallisii is named in honor of Gustav Wallis (1830–1878), German botanist and explorer who discovered this cycad in 1873. Chromosome number $2n = 16$. **Stems** subterranean, tuberous, 15–20 cm (6–8 in) long, 8–15 cm (3.2–6 in) in diameter. Cataphylls short triangular, tomentose, about 16 mm (0.6 in) long and 13 mm (0.5 in) wide at the base. **Leaves** usually one, rarely two, 1–2 m (3.3–6.6 ft) long, 1 m (3.3 ft) wide. Petiole 0.5–1 m (1.6–3.3 ft) long and armed in the lower two-thirds with prickles 4 mm long. Leaflets in one to four pairs, dark green, 36–60 cm (14–24 in) long, 12–26.5 cm (4.7–10.4 in) wide, the petiolule 6.5–7.5 cm (2.6–3 in) long, veins depressed above and raised below, giving a corrugated appearance to the upper surface, margin irregularly toothed in the apical third of the leaflet. **Female cones** with sarcotesta red when ripe. Sclerotesta ovoid, 10–15 mm (0.4–0.6 in) long, 10–12 mm (0.4–0.5 in) in diameter. **Male cones** one to seven (or more?), usually numerous, cylindrical, 4.2–5.5 cm (1.6–2.2 in) long, 1.3–1.6 cm (0.5–0.6 in) in diameter, white to light brown tomentose. Peduncle erect to drooping, 4.9–8.1 cm (2–3.2 in) long, 5–7 mm (0.2–0.3 in) in diameter, tomentose. Sporophylls hexagonal, evenly and densely tomentose, the facets distinct, the terminal facet concave. Sporangia in two small groups on the underside of the sporophyll. **Habitat:** Wet tropical rain forest at an elevation of about 900 m (3000 ft), generally on steep hillsides and hilltops. **Distribution:** Colombia, Antioquia department, western Andes near the town of Frontino.

Gustav Wallis discovered *Zamia wallisii* on an expedition to Colombia in 1873 while working as a plant collector for the Veitch Nursery in England. In 1875 Alexander Carl Heinrich Braun, of Berlin, formally described the species. *Zamia wallisii* was then lost to cultivation and science for more than a century. There had been several attempts in the ensuing years to rediscover this cycad, all unsuccessful. Then, early in the 1980s, a young Colombian botanist rediscovered *Z. wallisii* while working in the same area that Wallis had visited. A joint expedition was mounted by the Fairchild Tropical Garden, Miami, Florida, and the Botanical Garden, University of Naples, Italy. Plants were located and specimens collected for display and research at both institutions. A sizable colony was discovered on a mountaintop covered with primary rain forest. The sides of this mountain had been cleared for planting bananas and pineapples, and the mountaintop itself is in danger of the same fate.

Zamia wallisii is unique among cycads in producing the largest leaflets. These huge leaflets are no doubt an adaptation for gathering sufficient light in its dark rain forest environment. This cycad is also unusual in that its leaflets are attached to the rachis by a petiolule, a leaflet stalk or stem between the base of the leaflet and the rachis.

The scarcity of *Zamia wallisii* in collections and the short time it has been in cultivation since its rediscovery make it difficult to assess its horticultural requirements. Plants in the collection of the Fairchild Tropical Garden have not done well when planted outdoors, even in the tropical climate of Miami. The specimens grown in the tropical display house, with slightly warmer temperatures, have done very well. This would indicate that except in very tropical climates, *Z. wallisii* should be grown under greenhouse conditions in a warm, humid atmosphere. One of the specimens at the Fairchild Tropical Garden has coned and it proved to be a male. I have never seen a photograph of a female cone, nor do I know if one exists. It is hoped that both sexes will be coned in cultivation and artificial pollination successfully accomplished. This beautiful, rare, unique *Zamia* must receive as much assistance as possible to multiply its numbers. Neither seeds, seedlings, nor female cones have been reported in its habitat, indicating that several years might elapse between coning cycles.

The conservation status of *Zamia wallisii* is not good. Much of its habitat has been cleared for agriculture and there is no indication that this trend will stop. *Ex situ* colonies must be established in cultivation before this beautiful and interesting cycad becomes extinct in the wild. It must be considered extremely endangered.

Cycads for Particular Purposes

The following lists are provided for readers who wish to know which cycads have particular design or horticultural characteristics. For design, cycads are listed by growth habit, leaf length, leaf color, leaf shape, leaf persistence, and cone color. For horticulture, cycads are listed by climate preference, growth rate, and tolerance to a variety of factors such as drought and heat, cold, moist soils, sun, shade, salt, and wind.

Design Characteristics

Stems

Cycads may be divided into two groups by stem character: subterranean to shortly emergent, and arborescent or treelike. Subterranean stemmed cycads, such as *Encephalartos villosus* generally have all or most of their stem underground, whereas arborescent cycads such as *E. altensteinii* may with time produce aerial stems as tall as 5–6 m (16–20 ft). Occasionally, cycads that are generally subterranean or shortly emergent such as *Macrozamia communis* may with time develop into shortly arborescent plants.

Cycads with Subterranean Stems

Bowenia
Ceratozamia
- *C. hildae*
- *C. kuesteriana*
- *C. microstrobila*
- *C. miqueliana*
- *C. sabatoi*
- *C. whitelockiana*
- *C. zaragozae*

Cycas
- *C. bifida*
- *C. debaoensis*
- *C. micholitzii*
- *C. multipinnata*

Encephalartos
- *E. aplanatus*
- *E. barteri*
- *E. caffer*
- *E. cerinus*
- *E. cupidus*
- *E. humilis*
- *E. ngoyanus*
- *E. umbeluziensis*
- *E. villosus*

Macrozamia
- *M. diplomera*
- *M. douglasii*
- *M. fawcettii*
- *M. fearnsidei*
- *M. flexuosa*
- *M. glaucophylla*
- *M. heteromera*
- *M. lomandroides*
- *M. longispina*
- *M. lucida*
- *M. miquelii*
- *M. mountperriensis*
- *M. parcifolia*
- *M. pauli-guilielmi*
- *M. platyrachis*
- *M. plurinervia*
- *M. polymorpha*
- *M. reducta*
- *M. secunda*
- *M. spiralis*
- *M. stenomera*
- *M. viridis*

Stangeria eriopus
Zamia
- *Z. acuminata*
- *Z. amblyphyllidia*
- *Z. angustifolia*
- *Z. cremnophila*
- *Z. fischeri*
- *Z. furfuracea*
- *Z. integrifolia*
- *Z. kickxii*
- *Z. lacandona*
- *Z. loddigesii*
- *Z. lucayana*
- *Z. manicata*
- *Z. muricata*
- *Z. paucijuga*
- *Z. polymorpha*
- *Z. portoricensis*
- *Z. pumila*
- *Z. purpurea*
- *Z. pygmaea*
- *Z. spartea*
- *Z. splendens*
- *Z. standleyi*
- *Z. variegata*
- *Z. vazquezii*

Treelike Cycads

Ceratozamia
C. mexicana
C. norstogii
C. robusta
Cycas
C. angulata
C. apoa
C. armstrongii
C. basaltica
C. brunnea
C. cairnsiana
C. calcicola
C. chamberlainii
C. circinalis
C. conferta
C. couttsiana
C. curranii
C. furfuracea
C. lane-poolei
C. litoralis
C. maconochiei
C. media
C. megacarpa
C. micronesica
C. ophiolitica
C. panzhihuaensis
C. pectinata
C. platyphylla
C. pruinosa
C. revoluta
C. rumphii
C. seemannii
C. siamensis
C. taitungensis
C. thouarsii
C. wadei
Dioon
Encephalartos
E. aemulans
E. altensteinii
E. arenarius
E. cycadifolius
E. dyerianus
E. eugene-maraisii
E. friderici-guilielmi
E. ghellinckii
E. gratus
E. hildebrandtii
E. horridus
E. inopinus
E. kisambo
E. laevifolius
E. lanatus
E. latifrons
E. laurentianus
E. lebomboensis
E. lehmannii
E. longifolius
E. manikensis
E. middelburgensis
E. msinganus
E. munchii
E. natalensis
E. nubimontanus
E. paucidentatus
E. princeps
E. sclavoi
E. senticosus
E. tegulaneus
E. transvenosus
E. trispinosus
E. whitelockii
E. woodii
Lepidozamia
Macrozamia
M. dyeri
M. johnsonii
M. macdonnellii
M. moorei
M. riedlei
Microcycas calocoma
Zamia
Z. chigua
Z. encephalartoides
Z. fairchildiana
Z. inermis
Z. lindenii
Z. neurophyllidia
Z. obliqua
Z. poeppigiana
Z. roezlii
Z. skinneri
Z. soconuscensis
Z. tuerckheimii

Epiphytic Cycads

Only one cycad is known that is truly epiphytic, *Zamia pseudoparasitica.* There are also one or two species that have been found growing on rotting tree trunks, but they are not true epiphytes. *Zamia pseudoparasitica* can be planted in trees in subtropical to tropical climates, and it makes an interesting focal point with pendent, leathery leaves, as long as 3 m (10 ft).

Leaf Length

The various species of cycads produce leaves that range in length from 0.3 m (1 ft) to more than 6 m (20 ft). Knowledge of leaf length is essential in planning landscape designs or plantings properly, especially when starting with immature plants. I have divided cycads into four categories by leaf length: short, 0.3–1 m (1–3.3 ft); medium, 1–2 m (3.3–6.6 ft); long, 3–4 m (10–13 ft); and very long, 4–6 m (13–20 ft). Keep in mind that leaf length can vary depending on the amount of sun (or shade) the plant receives. Leaf lengths below are based on sun-loving plants grown in full sun, and shade-loving plants grown in full shade.

Cycads with Short Leaves, 0.3–1 m (1–3.3 ft)

Ceratozamia
C. latifolia
C. microstrobila
C. sabatoi
C. zaragozae
Dioon edule var. *angustifolium*
Encephalartos
E. caffer
E. cerinus
E. cupidus
E. humilis
E. ngoyanus
Macrozamia
M. fawcettii
M. fearnsidei
M. flexuosa
M. glaucophylla
M. lomandroides
M. parcifolia
M. pauli-guilielmi
M. platyrachis
M. plurinervia
M. polymorpha
M. secunda
M. spiralis
M. stenomera
M. viridis
Zamia
Z. acuminata
Z. amblyphyllidia
Z. angustifolia
Z. fischeri
Z. furfuracea
Z. inermis
Z. integrifolia
Z. kickxii
Z. loddigesii
Z. lucayana
Z. portoricensis
Z. pumila
Z. purpurea
Z. pygmaea
Z. spartea
Z. splendens
Z. vazquezii

Cycads with Medium Leaves, 1–2 m (3.3–6.6 ft)

- *Bowenia*
  - *B. serrulata*
  - *B. spectabilis*
- *Ceratozamia*
  - *C. hildae*
  - *C. kuesteriana*
  - *C. latifolia*
  - *C. mexicana*
  - *C. miqueliana*
  - *C. norstogii*
- *Cycas*
  - *C. angulata*
  - *C. basaltica*
  - *C. brunnea*
  - *C. cairnsiana*
  - *C. calcicola*
  - *C. chamberlainii*
  - *C. circinalis*
  - *C. conferta*
  - *C. couttsiana*
  - *C. furfuracea*
  - *C. lane-poolei*
  - *C. maconochiei*
  - *C. media*
  - *C. megacarpa*
  - *C. micronesica*
  - *C. ophiolitica*
  - *C. panzhihuaensis*
  - *C. platyphylla*
  - *C. pruinosa*
  - *C. revoluta*
  - *C. rumphii*
  - *C. seemannii*
  - *C. siamensis*
  - *C. taitungensis*
  - *C. wadei*
- *Dioon*
  - *D. califanoi*
  - *D. caputoi*
  - *D. edule* var. *edule*
  - *D. holmgrenii*
  - *D. mejiae*
  - *D. merolae*
  - *D. purpusii*
  - *D. rzedowskii*
  - *D. sonorense*
  - *D. spinulosum*
  - *D. tomasellii*
- *Encephalartos*
  - *E. aemulans*
  - *E. altensteinii*
  - *E. arenarius*
  - *E. barteri*
  - *E. bubalinus*
  - *E. concinnus*
  - *E. dolomiticus*
  - *E. dyerianus*
  - *E. eugene-maraisii*
  - *E. ferox*
  - *E. friderici-guilielmi*
  - *E. ghellinckii*
  - *E. gratus*
  - *E. horridus*
  - *E. inopinus*
  - *E. laevifolius*
  - *E. lanatus*
  - *E. latifrons*
  - *E. lebomboensis*
  - *E. lehmannii*
  - *E. longifolius*
  - *E. manikensis*
  - *E. middelburgensis*
  - *E. msinganus*
  - *E. munchii*
  - *E. nubimontanus*
  - *E. paucidentatus*
  - *E. princeps*
  - *E. sclavoi*
  - *E. senticosus*
  - *E. tegulaneus*
  - *E. trispinosus*
  - *E. umbeluziensis*
- *Macrozamia*
  - *M. communis*
  - *M. diplomera*
  - *M. fraseri*
  - *M. longispina*
  - *M. lucida*
  - *M. miquelii*
  - *M. mountperriensis*
  - *M. reducta*
  - *M. riedlei*
- *Microcycas calocoma*
- *Stangeria eriopus*
- *Zamia*
  - *Z. cremnophila*
  - *Z. encephalartoides*
  - *Z. inermis*
  - *Z. lacandona*
  - *Z. manicata*
  - *Z. muricata*
  - *Z. neurophyllidia*
  - *Z. obliqua*
  - *Z. paucijuga*
  - *Z. polymorpha*
  - *Z. skinneri*
  - *Z. soconuscensis*
  - *Z. tuerckheimii*
  - *Z. variegata*

Cycads with Long Leaves, 3–4 m (10–13 ft)

- *Ceratozamia*
  - *C. robusta*
  - *C. whitelockiana*
- *Cycas*
  - *C. apoa*
  - *C. curranii*
  - *C. litoralis*
  - *C. micholitzii*
  - *C. thouarsii*
- *Encephalartos*
  - *E. aplanatus*
  - *E. hildebrandtii*
  - *E. kisambo*
  - *E. natalensis*
  - *E. transvenosus*
  - *E. villosus*
  - *E. woodii*
- *Lepidozamia*
  - *L. hopei*
  - *L. peroffskyana*
- *Macrozamia*
  - *M. douglasii*
  - *M. dyeri*
  - *M. johnsonii*
  - *M. macdonnellii*
  - *M. moorei*
- *Zamia*
  - *Z. chigua*
  - *Z. lindenii*
  - *Z. poeppigiana*
  - *Z. pseudoparasitica*
  - *Z. roezlii*

Cycads with Very Long Leaves, 4–6 m (13–20 ft)

- *Cycas*
  - *C. bifida*
  - *C. multipinnata*
- *Encephalartos*
  - *E. laurentianus*
  - *E. whitelockii*

Leaf Color

Leaf color in cycads can vary from light green to blue gray. In general, cycads with green leaves prefer more shade, and those with glaucous to blue-gray leaves prefer more sun. The only exceptions to this rule are some species of *Ceratozamia* that produce glaucous green leaves such as *C. miqueliana* and *C. whitelockiana.* Those species, like most others of the genus, prefer shaded areas. Since the majority of the cycads have green leaves, only those that have glaucous green or blue-gray leaves are listed. Any not listed below can be considered to have green leaves.

Cycads with Glaucous Green Leaves

Ceratozamia
- *C. euryphyllidia*
- *C. microstrobila*
- *C. miqueliana*
- *C. whitelockiana*

Cycas
- *C. angulata*
- *C. conferta*
- *C. lane-poolei*
- *C. maconochiei*
- *C. media*
- *C. megacarpa*
- *C. ophiolitica*
- *C. panzhihuaensis*
- *C. platyphylla*

Dioon
- *D. califanoi*
- *D. caputoi*
- *D. edule*
- *D. merolae*
- *D. sonorense*

Encephalartos
- *E. arenarius*
- *E. cerinus*
- *E. cupidus*
- *E. dolomiticus*
- *E. dyerianus*
- *E. eugene-maraisii*
- *E. friderici-guilielmi*
- *E. inopinus*
- *E. middelburgensis*
- *E. munchii*
- *E. nubimontanus*

Macrozamia
- *M. dyeri*
- *M. moorei*
- *M. riedlei*

Cycads with Blue-Gray Leaves

Ceratozamia zoquorum

Cycas
- *C. brunnea*
- *C. cairnsiana*
- *C. couttsiana*
- *C. desolata*
- *C. furfuracea*
- *C. pruinosa*

Encephalartos
- *E. arenarius,* blue form
- *E. hirsutus*
- *E. horridus*
- *E. humilis*
- *E. lanatus*
- *E. lehmannii*
- *E. longifolius,* blue form
- *E. princeps*
- *E. trispinosus*

Macrozamia macdonnellii

Leaf Shape

Leaf shape in cycads can generally be divided into five categories: straight, arching or curved, upright or plumose, fernlike, and pendent. Cycads with pendent leaves are thus modified because they grow on cliffs, or in trees as an epiphyte.

Cycads with Straight Leaves

Cycas
- *C. basaltica*
- *C. brunnea*
- *C. calcicola*
- *C. conferta*
- *C. desolata*
- *C. furfuracea*
- *C. hainanensis*
- *C. lane-poolei*
- *C. maconochiei*
- *C. panzhihuaensis*
- *C. revoluta*
- *C. taitungensis*

Dioon
- *D. caputoi*
- *D. edule*
- *D. holmgrenii*
- *D. merolae*
- *D. sonorense*
- *D. tomasellii*

Encephalartos
- *E. aemulans*
- *E. altensteinii*
- *E. barteri*
- *E. bubalinus*
- *E. caffer*
- *E. cerinus*
- *E. chimanimaniensis*
- *E. concinnus*
- *E. cupidus*
- *E. cycadifolius*
- *E. dolomiticus*
- *E. eugene-maraisii*
- *E. friderici-guilielmi*
- *E. ghellinckii*
- *E. hildebrandtii*
- *E. kisambo*
- *E. lebomboensis*
- *E. middelburgensis*
- *E. msinganus*
- *E. munchii*
- *E. natalensis*
- *E. nubimontanus*
- *E. paucidentatus*
- *E. sclavoi*
- *E. tegulaneus*
- *E. transvenosus*
- *E. turneri*
- *E. umbeluziensis*
- *E. whitelockii*

Macrozamia diplomera

Microcycas calocoma

Zamia
- *Z. inermis*
- *Z. loddigesii*
- *Z. lucayana*

Cycads with Arching or Curved Leaves

Ceratozamia
- *C. euryphyllidia*
- *C. kuesteriana*
- *C. latifolia*
- *C. matudae*
- *C. mexicana*
- *C. miqueliana*
- *C. robusta*
- *C. sabatoi*

Cycas
- *C. angulata*
- *C. apoa*
- *C. armstrongii*
- *C. bougainvilleana*
- *C. cairnsiana*
- *C. chamberlainii*
- *C. curranii*
- *C. guizhouensis*
- *C. litoralis*
- *C. macrocarpa*
- *C. media*
- *C. megacarpa*
- *C. micronesica*
- *C. platyphylla*
- *C. pruinosa*
- *C. rumphii*
- *C. seemannii*
- *C. thouarsii*

Dioon
- *D. mejiae*
- *D. rzedowskii*
- *D. spinulosum*

Encephalartos
- *E. aplanatus*
- *E. arenarius*
- *E. ferox*
- *E. horridus*
- *E. humilis*
- *E. lanatus*
- *E. latifrons*
- *E. lehmannii*
- *E. longifolius*
- *E. princeps*
- *E. trispinosus*
- *E. villosus*

Lepidozamia hopei

Macrozamia
- *M. communis*

Cycads with Arching or Curved Leaves continued

M. douglasii
M. elegans
M. glaucophylla
M. johnsonii
M. longispina
M. lucida
M. macdonnellii
M. miquelii
M. moorei
M. mountperriensis
M. reducta
M. riedlei
M. secunda
Zamia
Z. acuminata
Z. amblyphyllidia
Z. fairchildiana
Z. fischeri
Z. integrifolia
Z. lindenii
Z. muricata
Z. neurophyllidia
Z. obliqua
Z. poeppigiana
Z. pumila
Z. pygmaea
Z. skinneri
Z. soconuscensis
Z. spartea
Z. splendens
Z. standleyi
Z. tuerckheimii
Z. variegata
Z. vazquezii

Cycads with Upright or Plumose Leaves

Ceratozamia
C. hildae
C. norstogii
C. zaragozae
Cycas
C. bifida
C. debaoensis
C. micholitzii
C. multipinnata
Macrozamia
M. fawcettii
M. fearnsidei
M. flexuosa
M. lomandroides
M. parcifolia
M. pauli-guilielmi
M. plurinervia
M. stenomera
M. viridis

Cycads with Fernlike Leaves

Bowenia
B. serrulata
B. spectabilis
Chigua
C. bernalii
C. restrepoi
Stangeria eriopus
Zamia
Z. fischeri
Z. vazquezii

Cycads with Pendent Leaves

Ceratozamia morettii
Zamia
Z. cremnophila
Z. pseudoparasitica

Leaf Persistence

Some cycads exhibit a deciduous or semideciduous growth pattern. These are generally plants of grassland areas that experience annual fires. It should be noted that some of these plants lose their deciduous habit when cultivated. The cycads not listed here are evergreen.

Cycads That Are Deciduous or Semideciduous

Cycas
C. armstrongii
C. circinalis
C. conferta
C. lane-poolei
C. ophiolitica
C. siamensis
Encephalartos
E. barteri
E. caffer
E. humilis
E. ngoyanus
Microcycas calocoma
Stangeria eriopus

Cone Color

Most cycads have female and male cones in various shades of green but a few produce cones that are red, orange, yellow, blue-gray, woolly white, or reddish brown. The species with colorful cones can often be used to good effect in a landscape design. Species such as *Encephalartos ferox* can produce cones that are red, orange, or yellow and when properly placed in the garden will produce a notable visual effect. Keep in mind that cones of male plants last only a few weeks whereas female cones can remain on the plant in good color as long as 12 months.

Cycads with Red to Orange Cones

Cycas, almost all species have heavily tomentose yellow to orange cones
Encephalartos
E. ferox
E. kisambo

Cycads with Yellow Cones

Encephalartos
E. altensteinii
E. cerinus
E. ferox
E. hildebrandtii
E. lebomboensis
E. natalensis
E. paucidentatus
E. sclavoi
E. tegulaneus
E. transvenosus
E. villosus
E. woodii
Macrozamia lucida

Cycads with Glaucous Blue-Gray Cones

Encephalartos
E. arenarius
E. dyerianus
E. munchii
Macrozamia
M. communis
M. johnsonii
M. moorei

Cycads with White to Gray Tomentose Cones

Dioon
Encephalartos
E. cycadifolius
E. friderici-guilielmi
E. ghellinckii
E. humilis
E. lanatus

Cycads with Reddish Brown Cones

Encephalartos
E. eugene-maraisii
E. horridus
E. lehmannii
E. middelburgensis

Horticultural Characteristics

Climate Preference

The majority of the cycads are found between the tropics of Cancer and Capricorn. This indicates their preference for warm to hot growing conditions, but because of their ability to acclimate to cooler climates, many can be grown outdoors in temperate to warm temperate areas. Here, cycads are divided into those that will generally grow in temperate to warm temperate climates, and those that require subtropical to tropical climates.

Temperate to Warm Temperate Cycads

Bowenia serrulata
Ceratozamia
C. alvarezii
C. hildae
C. kuesteriana
C. latifolia
C. matudae
C. mexicana
C. microstrobila
C. mixeorum
C. norstogii
C. robusta
C. sabatoi
C. whitelockiana
C. zaragozae
Cycas
C. angulata
C. beddomei
C. cairnsiana
C. chamberlainii
C. circinalis
C. couttsiana
C. desolata
C. furfuracea
C. hainanensis
C. media
C. megacarpa
C. ophiolitica
C. panzhihuaensis
C. platyphylla
C. revoluta
C. seemannii
C. simplicipinna
C. taitungensis
C. tansachana
C. thouarsii
C. wadei
Dioon
Encephalartos
E. aemulans
E. altensteinii
E. aplanatus
E. arenarius
E. bubalinus
E. caffer
E. cerinus
E. chimanimaniensis
E. concinnus
E. cupidus
E. cycadifolius

Temperate to Warm Temperate Cycads continued

E. dolomiticus
E. dyerianus
E. equatorialis
E. eugene-maraisii
E. ferox
E. friderici-guilielmi
E. ghellinckii
E. gratus
E. hildebrandtii
E. horridus
E. humilis
E. inopinus
E. kisambo
E. laevifolius
E. lanatus
E. latifrons
E. lebomboensis
E. lehmannii
E. longifolius
E. manikensis
E. middelburgensis
E. msinganus
E. munchii
E. natalensis
E. ngoyanus
E. nubimontanus
E. paucidentatus
E. princeps
E. pterogonus
E. sclavoi
E. senticosus
E. tegulaneus
E. transvenosus
E. trispinosus
E. umbeluziensis
E. villosus
E. whitelockii
E. woodii
Lepidozamia peroffskyana
Macrozamia
Stangeria eriopus
Zamia
Z. amblyphyllidia
Z. angustifolia
Z. fischeri
Z. furfuracea
Z. inermis
Z. integrifolia
Z. loddigesii
Z. lucayana
Z. paucijuga
Z. portoricensis
Z. pumila
Z. pygmaea
Z. spartea
Z. splendens
Z. standleyi
Z. vazquezii

Subtropical to Tropical Cycads

Bowenia spectabilis
Ceratozamia
C. euryphyllidia
C. miqueliana
Chigua
Cycas
C. apoa
C. arenicola
C. armstrongii
C. arnhemica
C. basaltica
C. campestris
C. canalis
C. clivicola
C. conferta
C. curranii
C. lane-poolei
C. litoralis
C. maconochiei
C. micholitzii
C. micronesica
C. pruinosa
C. rumphii
C. siamensis
C. simplicipinna
Encephalartos
E. barteri
E. ituriensis
E. laurentianus
E. poggei
E. schmitzii
Lepidozamia hopei
Microcycas calocoma
Zamia
Z. acuminata
Z. chigua
Z. dressleri
Z. encephalartoides
Z. fairchildiana
Z. lacandona
Z. lindenii
Z. lindleyi
Z. manicata
Z. muricata
Z. neurophyllidia
Z. obliqua
Z. pseudoparasitica
Z. purpurea
Z. roezlii
Z. skinneri
Z. tuerckheimii
Z. variegata

Growth Rate

Growth rates of cycads vary considerably from species to species. Cycads from more tropical climates tend to have a more rapid growth rate whereas those from temperate and warm temperate climates tend to be slow to moderate in their growth rate. Listed here are those cycads that in my experience have been very rapid in their growth from seedling to maturity. Cycads not listed may be considered to be slow to moderate in growth rate. Keep in mind that the proper growing conditions may speed growth in the slower growing species.

Cycads with Rapid Growth Rates

Cycas
C. apoa
C. bifida
C. campestris
C. curranii
C. litoralis
C. macrocarpa
C. micholitzii
C. micronesica
C. revoluta
C. rumphii
C. taitungensis
C. thouarsii
Encephalartos
E. altensteinii
E. arenarius
E. ferox
E. gratus
E. hildebrandtii
E. kisambo
E. laurentianus
E. manikensis
E. natalensis
E. transvenosus
E. villosus
E. whitelockii
Lepidozamia peroffskyana
Macrozamia
M. communis
M. douglasii
M. johnsonii
M. moorei
Zamia
Z. amblyphyllidia
Z. fairchildiana
Z. furfuracea
Z. lindenii
Z. muricata
Z. poeppigiana
Z. roezlii
Z. soconuscensis

Drought Tolerance

Many cycads are very tolerant of dry growing conditions and excessive heat. The cycads that fall into this category generally are those with the glaucous green to blue-gray leaves, but there are a number of green-leaved cycads that also tolerate drought and heat. The glaucous green to blue-gray leaf coloration is the result of a waxy coating on the surface of the leaflets, which helps reduce water loss while reflecting much of the sun's heat.

Cycads That Tolerate Drought and Heat

- *Ceratozamia*
  - *C. microstrobila*
  - *C. zaragozae*
- *Cycas*
  - *C. angulata*
  - *C. armstrongii*
  - *C. basaltica*
  - *C. beddomei*
  - *C. brunnea*
  - *C. cairnsiana*
  - *C. calcicola*
  - *C. circinalis*
  - *C. couttsiana*
  - *C. desolata*
  - *C. furfuracea*
  - *C. lane-poolei*
  - *C. media*
  - *C. megacarpa*
  - *C. ophiolitica*
  - *C. panzhihuaensis*
  - *C. platyphylla*
  - *C. pruinosa*
- *Dioon*
  - *D. califanoi*
  - *D. caputoi*
  - *D. edule*
  - *D. holmgrenii*
  - *D. purpusii*
  - *D. sonorense*
  - *D. tomasellii*
- *Encephalartos*
  - *E. caffer*
  - *E. cerinus*
  - *E. cupidus*
  - *E. cycadifolius*
  - *E. dolomiticus*
  - *E. dyerianus*
  - *E. eugene-maraisii*
  - *E. friderici-guilielmi*
  - *E. horridus*
  - *E. humilis*
  - *E. inopinus*
  - *E. laevifolius*
  - *E. lanatus*
  - *E. latifrons*
  - *E. lebomboensis*
  - *E. lehmannii*
  - *E. longifolius*
  - *E. middelburgensis*
  - *E. munchii*
  - *E. nubimontanus*
  - *E. princeps*
  - *E. trispinosus*
- *Macrozamia*
  - *M. dyeri*
  - *M. fraseri*
  - *M. glaucophylla*
  - *M. macdonnellii*
  - *M. riedlei*
- *Microcycas calocoma*
- *Stangeria eriopus*
- *Zamia encephalartoides*

Cold Tolerance

A few cycads grow at high elevations where winter frost and snow occur. These cycads show exceptional cold hardiness in cultivation, but cycads that tolerate cold often do poorly in hot or tropical climates. Although the following cycads display some degree of cold hardiness, most will not tolerate extended periods of subfreezing temperatures.

Cycads That Tolerate Cold and Frost

- *Ceratozamia*
  - *C. kuesteriana*
  - *C. latifolia*
  - *C. mexicana*
  - *C. sabatoi*
  - *C. zaragozae*
- *Cycas*
  - *C. couttsiana*
  - *C. megacarpa*
  - *C. ophiolitica*
  - *C. panzhihuaensis*
  - *C. revoluta*
  - *C. taitungensis*
  - *C. wadei*
- *Dioon*
  - *D. califanoi*
  - *D. caputoi*
  - *D. edule*
  - *D. purpusii*
  - *D. sonorense*
  - *D. tomasellii*
- *Encephalartos*
  - *E. altensteinii*
  - *E. arenarius*
  - *E. caffer*
  - *E. cycadifolius*
  - *E. eugene-maraisii*
  - *E. friderici-guilielmi*
  - *E. ghellinckii*
  - *E. horridus*
  - *E. lanatus*
  - *E. latifrons*
  - *E. lebomboensis*
  - *E. lehmannii*
  - *E. longifolius*
  - *E. natalensis*
  - *E. princeps*
  - *E. sclavoi*
  - *E. senticosus*
  - *E. tegulaneus*
  - *E. transvenosus*
  - *E. trispinosus*
  - *E. woodii*
- *Lepidozamia peroffskyana*
- *Macrozamia*
- *Stangeria eriopus*
- *Zamia*
  - *Z. fischeri*
  - *Z. furfuracea*
  - *Z. inermis*
  - *Z. integrifolia*
  - *Z. kickxii*
  - *Z. loddigesii*
  - *Z. lucayana*
  - *Z. paucijuga*
  - *Z. pumila*
  - *Z. spartea*
  - *Z. splendens*
  - *Z. standleyi*
  - *Z. vazquezii*

Moisture Tolerance

Numerous cycads from the Tropics grow in areas of high rainfall and high humidity. Some cycads are even found growing in low, marshy areas, but even those species generally grow only on raised areas that afford them reasonable drainage.

Cycads That Tolerate Moist or Wet Soils

- *Bowenia spectabilis*
- *Ceratozamia*
  - *C. euryphyllidia*
  - *C. hildae*
  - *C. kuesteriana*
  - *C. miqueliana*
  - *C. robusta*
  - *C. whitelockiana*
- *Cycas*
  - *C. curranii*
  - *C. hainanensis*
- *Dioon*
  - *D. mejiae*
  - *D. rzedowskii*
  - *D. spinulosum*
- *Encephalartos*
  - *E. ferox*
  - *E. gratus*
  - *E. hildebrandtii*
  - *E. kisambo*
  - *E. transvenosus*
  - *E. villosus*
  - *E. whitelockii*
- *Lepidozamia hopei*
- *Macrozamia*
  - *M. douglasii*
  - *M. lucida*
- *Zamia*
  - *Z. chigua*
  - *Z. dressleri*
  - *Z. fairchildiana*
  - *Z. furfuracea*
  - *Z. lacandona*
  - *Z. lindenii*
  - *Z. lindleyi*
  - *Z. neurophyllidia*
  - *Z. roezlii*
  - *Z. skinneri*
  - *Z. soconuscensis*
  - *Z. splendens*
  - *Z. tuerckheimii*
  - *Z. variegata*

Sun Tolerance

Many cycads grow in full sun in their natural habitats. Almost all cycads with glaucous green to blue-gray leaves belong to this group, but there are many green-leaved cycads that can also be grown in full sun.

Cycads That Tolerate Sun

- *Cycas*
  - *C. angulata*
  - *C. basaltica*
  - *C. brunnea*
  - *C. cairnsiana*
  - *C. calcicola*
  - *C. couttsiana*
  - *C. desolata*
  - *C. furfuracea*
  - *C. lane-poolei*
  - *C. maconochiei*
  - *C. media*
  - *C. megacarpa*
  - *C. ophiolitica*
  - *C. panzhihuaensis*
  - *C. platyphylla*
  - *C. pruinosa*
  - *C. revolute and*
  - *C. siamensis*
  - *C. taitungensis*
- *Dioon*
  - *D. califanoi*
  - *D. caputoi*
  - *D. edule*
  - *D. holmgrenii*
  - *D. merolae*
  - *D. purpose*
  - *D. sonorense*
- *Encephalartos*
  - *E. aemulans*
  - *E. altensteinii*
  - *E. arenarius*
  - *E. barteri*
  - *E. caffer*
  - *E. cerinus*
  - *E. cupidus*
  - *E. cycadifolius*
  - *E. dolomiticus*
  - *E. dyerianus*
  - *E. eugene-maraisii*
  - *E. friderici-guilielmi*
  - *E. ghellinckii*
  - *E. horridus*
  - *E. humilis*
  - *E. inopinus*
  - *E. laevifolius*
  - *E. lanatus*
  - *E. latifrons*
  - *E. lebomboensis*
  - *E. lehmannii*
  - *E. longifolius*
  - *E. middelburgensis*
  - *E. munchii*
  - *E. nubimontanus*
  - *E. princeps*
  - *E. transvenosus*
  - *E. trispinosus*
- *Lepidozamia peroff-skyana*
- *Macrozamia*
  - *M. communis*
  - *M. diplomera*
  - *M. dyeri*
  - *M. glaucophylla*
  - *M. macdonnellii*
  - *M. miquelii*
  - *M. moorei*
  - *M. riedlei*
- *Microcycas calocoma*
- *Stangeria eriopus,* grassland form
- *Zamia*
  - *Z. angustifolia*
  - *Z. furfuracea*
  - *Z. inermis*
  - *Z. integrifolia*
  - *Z. loddigesii*
  - *Z. lucayana*
  - *Z. paucijuga*
  - *Z. pygmaea*
  - *Z. spartea*

Shade Tolerance

The cycads listed here are those that will grow well in moderate to full shade. These species generally tolerate some morning sun, when air temperatures are cooler.

Cycads That Tolerate Shade

- *Bowenia*
- *Ceratozamia*
- *Chigua*
- *Cycas*
  - *C. armstrongii*
  - *C. bifida*
  - *C. chamberlainii*
  - *C. curranii*
  - *C. litoralis*
  - *C. micholitzii*
  - *C. micronesica*
  - *C. multipinnata*
  - *C. silvestris*
  - *C. simplicipinna*
  - *C. thouarsii*
- *Dioon*
  - *D. mejiae*
  - *D. rzedowskii*
  - *D. spinulosum*
- *Encephalartos*
  - *E. aplanatus*
  - *E. arenarius*
  - *E. ferox*
  - *E. gratus*
  - *E. hildebrandtii*
  - *E. kisambo*
  - *E. laurentianus*
  - *E. paucidentatus*
  - *E. tegulaneus*
  - *E. transvenosus*
  - *E. umbeluziensis*

Cycads That Tolerate Shade continued

Encephalartos continued
- *E. villosus*
- *E. whitelockii*
- *E. woodii*

Lepidozamia
- *L. hopei*
- *L. peroffskyana*

Macrozamia
- *M. communis*
- *M. douglasii*
- *M. elegans*
- *M. fawcettii*
- *M. flexuosa*
- *M. johnsonii*
- *M. lomandroides*
- *M. longispina*
- *M. lucida*
- *M. miquelii*
- *M. moorei*
- *M. mountperriensis*
- *M. pauli-guilielmi*
- *M. platyrachis*
- *M. stenomera*
- *M. viridis*

Stangeria eriopus

Zamia
- *Z. acuminata*
- *Z. amblyphyllidia*
- *Z. cremnophila*
- *Z. dressleri*
- *Z. fairchildiana*
- *Z. fischeri*
- *Z. lindenii*
- *Z. manicata*
- *Z. muricata*
- *Z. neurophyllidia*
- *Z. obliqua*
- *Z. pumila*
- *Z. purpurea*
- *Z. skinneri*
- *Z. soconuscensis*
- *Z. splendens*
- *Z. standleyi*
- *Z. tuerckheimii*
- *Z. variegata*

Salt Tolerance

A few cycads exhibit considerable tolerance of salty conditions. These species are often found growing in areas close to the ocean, where they are exposed to salt water carried by wind or high tides.

Cycads That Tolerate Salt

Bowenia serrulata

Cycas
- *C. armstrongii*
- *C. clivicola*
- *C. lindstromii*
- *C. litoralis*
- *C. micronesica*
- *C. revoluta*
- *C. rumphii*
- *C. silvestris*

Dioon
- *D. edule*
- *D. mejiae*

Encephalartos
- *E. ferox*
- *E. hildebrandtii*

Macrozamia
- *M. communis*
- *M. douglasii*
- *M. miquelii*
- *M. pauli-guilielmi*

Zamia
- *Z. angustifolia*
- *Z. furfuracea*
- *Z. integrifolia*
- *Z. loddigesii*
- *Z. lucayana*
- *Z. paucijuga*
- *Z. pumila*
- *Z. roezlii*

Wind Tolerance

Generally, most cycads tolerate moderate amounts of wind, that is, gusts less than 100 km (62 miles) per hour. Wind tolerance, with a few exceptions, can be categorized by genus rather than individual species. *Dioon* and *Encephalartos* are very wind tolerant whereas *Ceratozamia* is not. In the genus *Zamia*, most species are not wind tolerant, but there are a number of species that are.

Cycads That Tolerate Wind

Cycas

Dioon

Encephalartos

Lepidozamia

Macrozamia

Microcycas calocoma

Stangeria eriopus

Zamia
- *Z. amblyphyllidia*
- *Z. angustifolia*
- *Z. angustissima*
- *Z. encephalartoides*
- *Z. fischeri*
- *Z. furfuracea*
- *Z. inermis*
- *Z. integrifolia*
- *Z. kickxii*
- *Z. lindleyi*
- *Z. loddigesii*
- *Z. lucayana*
- *Z. paucijuga*
- *Z. portoricensis*
- *Z. pseudoparasitica*
- *Z. pumila*
- *Z. pygmaea*
- *Z. roezlii*
- *Z. soconuscensis*
- *Z. spartea*
- *Z. vazquezii*

Glossary

acuminate. Ending in a long, tapering point
acute. Ending in a short, sharp point
alternate. Borne at different levels in straight lines or spirals, for example, leaflets
apical. Upper end, furthest from the point of attachment
apiculum (adjective, apiculate). A short point at the apex
arborescent. Treelike growth habit
armed. Bearing spines or prickles
articulated. Of leaflets that separate from the rachis when the leaf dies
bicornate. With two horns
bifid. Divided into two lobes by a cleft in the middle
bipinnate. Twice pinnately divided
bottom heat. In propagation, application of heat below a seed or cutting
calcareous. Of soil with an excess of calcium
callus (adjective, callous). Patch of tissue, often colored, at the base of leaflets
cataphyll. Reduced, scalelike leaf, often formed in flushes, alternating with flushes of leaves
chalaza. Point of attachment of the ovule or seed to the megasporophyll
circinate. Of leaves or leaflets, unfolding from a coiled configuration
collar. Band of tissue at the point of attachment, different in color and texture
compound. Of leaves divided into leaflets, either singly (pinnate), twice (bipinnate), or thrice (tripinnate)
compressed. Somewhat flattened
cone. Structure composed of sporophylls, bearing the reproductive organs
crown. Apex of the stem, usually covered with protective bracts or cataphylls through which cones or leaves emerge at intervals
cuneate. Triangular, the narrow end at the point of attachment
deciduous. Seasonal shedding of leaves
decumbent. Of stems, resting on the ground with the apex ascending
decurrent. Of a margin, extending down beyond the point of attachment
deflexed. Abruptly curved or bent downward
deltoid. Triangular, delta shaped
dichotomous. Of veins, forked into equal branches
disjunct. Naturally occurring populations or colonies of organisms, separated by a large distance
divided. Separated to the point of attachment
elliptical. Oval and narrowed toward each rounded end
elongate. Drawn out
endemic. Native and restricted to a particular area
epidermis. Thin layer of cells forming the outer surface of a plant
epiphyte. A plant growing nonparasitically on another
epithet. In a scientific name of an organism, the name of a particular species, following the name of the genus
erect. Upright
f. Abbreviation for the taxonomic rank of form
facet. Of a sporophyll, one of the flat surfaces into which the outer surface, the face, is usually divided; the middle facet is called the terminal facet
falcate. Sickle shaped
forked. Divided into equal or nearly equal halves
glabrous. Smooth, without hairs or other coverings
glaucous. Bluish green, often imparted by a waxy or powdery bloom on the epidermis
globose. Nearly spherical
indigenous. Native to a particular area but not necessarily restricted there
juvenile. Growth before a cycad is capable of coning
keeled. Of leaves with leaflets held in a V
lacerate. Irregularly cut or torn

lamina. Of a *Cycas* sporophyll, the flatter portion, attached by a stalk to the cone's axis
lanceolate. Lance shaped, widening above the point of attachment, tapering toward the apex
lateral. At the side
leaf base. Point of attachment of the leaf to the stem, the expanded and sheathing part of the petiole
leaflet. One of the separate blades of a compound leaf
linear. Long and narrow, the sides parallel or nearly so
margin. Of a leaf or leaflet, the edge nearer the leaf base or the rachis (the lower margin, sometimes called the posterior or inferior margin) or the edge nearer the apex of the leaf or leaflet (the upper margin, sometimes called the anterior or superior margin)
median. Toward the middle, for example, the middle leaflets of a leaf or the middle sporophylls of a cone
megasporophyll. Female sporophyll or cone scale, bearing the ovules, later the seeds
micropyle. Opening in the ovule, at the end facing the central axis of the cone, where pollen enters
microsporophyll. Male sporophyll or cone scale, bearing the sporangia or pollen capsules
midrib. Of a leaflet, the main vein, usually in the center and extending the full length of the leaflet
mucronate. Ending abruptly in a short, sharp point
obovate. Egg shaped in a plane, the point of attachment at the narrow end
obovoid. Egg-shaped solid, the point of attachment at the narrow end
obtuse. Ending in a blunt or rounded end
offset. Shoot arising from the base of the stem or on the trunk
oval. Rounded but longer than wide
ovate. Egg shaped in a plane, the point of attachment at the broader end
ovoid. Egg-shaped solid
ovule. Structure that becomes a seed after fertilization
pectinate. With narrow, close-set divisions like a comb
peduncle. Stalk of a cone
petiole. Of a leaf, the basal portion of the rachis that is between the lowest leaflet or spine and the stem
petiolule. Of a leaflet, a stalk between the point of attachment to the rachis and the base of the leaflet
pinnate. Once divided, the divisions extending to the rachis
pungent. Ending in a stiff, sharp spine
rachis. Stalk of a compound leaf, including the petiole
radicle. Embryonic root of a germinating seed
revolute. Of a margin, rolled or curled backward toward the underside
rhombic. Of sporophylls, diamond shaped with equal sides
rhomboid. Of sporophylls, diamond shaped with unequal sides
sarcotesta. Outer fleshy layer of a cycad seed
scale. A small, dry, papery covering
sclerophyll. Referring to hard-leaved trees such as *Acacia* and *Eucalyptus*
sclerotesta. Hard inner layer of a cycad seed, surrounding the female gametophyte
sect. Abbreviation for the taxonomic rank of section
seed. Mature fertilized ovule, consisting of embryo, endosperm, sclerotesta, and sarcotesta
semiterete. Half-round in cross section
serpentine. Of shape, sinuous or snakelike; of a substrate, containing magnesium silicate and usually dull green
serrate. Toothed like a saw
serrulate. Minutely toothed
sessile. Without a stalk at the point of attachment
simple. Of leaves not divided into leaflets, as opposed to compound
sporangia. On microsporophylls, the capsules in which pollen is contained
sporophyll. Leaflike structure (consisting of a stalk and a lamina, the outer surface of which is called the sporophyll face) of a cone, bearing ovules (megasporophyll) or sporangia or pollen capsules (microsporophyll)
stomata. Pores in the epidermis for exchange of gas between the atmosphere and the plant
sub- . Prefix meaning nearly, less than, or somewhat
subsp. Abbreviation for the taxonomic rank of subspecies
succulent. Fleshy or juicy
sucker. Shoot arising from the base of the stem or the roots, below ground level
taxon (plural, taxa). A group of related organisms at any rank in the taxonomic hierarchy
teeth. Small, sharply tipped, sometimes spiny protuberances on the leaflet margin
terete. Cylindrical or round in cross section
tomentum (adjective, tomentose). Feltlike covering of hairs
tripinnate. Thrice pinnately divided
truncate. Ending abruptly as if cut off
tuber. Thickened underground stem
tuberous. Bearing a tuber or tubers
unarmed. Smooth, without spines or prickles
undulate. Of a margin, wavy up and down rather than in and out
var. Abbreviation for the taxonomic rank of variety
vein. One of the liquid-conducting structures of a leaf or leaflet

Bibliography

Adanson, M. 1763. Familles des Plantes, volume 2. Paris: Vincent [*Todda-pana*]

Aiton, W. 1789. Hortus Kewensis, volume 3. London: George Nicol. [*Zamia debilis, Z. furfuracea, Z. integrifolia, Z. pungens*]

André, É. 1875. *Zamia lindeni* Regel. Illustration Horticole 22: 23, pl. 195.

Ascherson, P. 1878. Vorlage von . . . afrikanischen Pflanzen von H. Soyaux und Dr. Pogge. Verhandlungen des Botanischen Vereins der Provinz Brandenburg 20: 34–36. [*Encephalartos poggei*]

Bailey, F. M. 1883. A Synopsis of the Queensland Flora. Brisbane: James C. Beal. [*Bowenia spectabilis* var. *serrata, Macrozamia douglasii*]

Bailey, F. M. 1886. A Synopsis of the Queensland Flora, supplement 1. Brisbane: Government Printer. [*Macrozamia hopei, M. mountperriensis*]

Bailey, F. M. 1898. Contributions to the flora of Queensland. Queensland Agricultural Journal 3: 353–356. [*Macrozamia platyrachis*]

Baillon, H. 1894. Cycadacées, *in* Histoire des Plantes, volume 12. Paris: Hachette. [*Stangeria eriopus*]

Bamps, P., & S. Lisowski. 1990. A new species of *Encephalartos* (Zamiaceae) from northeastern Zaire. Memoirs of the New York Botanical Garden 57: 152–155. [*E. ituriensis*]

Beaton, J. M. 1977. Dangerous Harvest. Ph.D. thesis. Canberra: Australian National University.

Beaton, J. M. 1982. Fire and water: aspects of Australian Aboriginal management of cycads. Archaeology in Oceania 17: 51–58.

Bentham, G. 1873. Cycadaceae, *in* Flora Australiensis, volume 6. London: Lowell Reeve. [*Macrozamia spiralis* var. *secunda*]

Bertoloni, G. 1851. Illustrazione di plante Mozambicesi. Memorie della R. Accademia delle Scienze dell'Istituto di Bologna 3: 249–267. [*Encephalartos ferox*]

Braun, A. 1875. Die Frage nach der Gymnospermie der Cycadeen erläutert durch die Stellung dieser Familie im Stufengang des Gewächsreichs. Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin 1875 (April): 241–377. [*Zamia montana, Z. obliqua, Z. wallisii*]

Braun, A. 1876. Bemerkungen über einige Cycadeen. Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin 1876: 113–125. [*Cycas seemannii*]

Braun, A., & C. D. Bouché. 1874. Plantae novae a cl. Hildebrandt ex Africa orientali allatae, a. 1874 in horto Berolinensi cultae. Index Seminum in Horto Botanico Berolinensis Anno 1874 Collectorum. [*Encephalartos hildebrandtii*]

Britton, N. L. 1909. Contributions to the flora of the Bahamas Islands IV. Bulletin of the New York Botanical Garden 5(18): 311–318. [*Zamia lucayana*]

Britton, N. L. 1916. Studies of West Indian plants. 51 undescribed species from the Isle of Pines, Cuba. Bulletin of the Torrey Botanical Club 43(9): 462–469. [*Zamia silicea*]

Brongniart, A. T. 1846. Note sur un nouveau genre de Cycadées du Mexique. Annales des Science Naturelles, sér. 3, 5: 5–10. [*Ceratozamia, C. boliviana, C. mexicana*]

Brown, R. 1810. Prodromus Florae Novae Hollandiae et Insulae Van-Diemen. London: J. Johnson. Reprinted in 1960 at Weinheim, Germany: J. Cramer. [*Cycas angulata, C. media*]

Brown, W. H., & R. Kienholz. 1925. *Cycas chamberlainii,* a new species. Philippine Journal of Science 26: 47–52.

Bruant, G. 1888. Catalogue Général, no. 195: 5. [*Cycas comorensis*]

Buchanan-Hamilton, F. 1826. Commentary on the Herbarium Amboinense. Memoirs of the Wernerian Natural History Society 5: 322–324. [*Cycas pectinata*]

Bull, W. 1872. Catalogue, no. 8. [*Stangeria schizodon*]

Bull, W. 1878. Catalogue, no. 4, pl. 5. [*Bowenia spectabilis* var. *serrulata*]

Bull, W. 1881. *Zamia prasina.* Catalogue, no. 20.

Calderón, S., & P. Standley. 1924. New species of plants from Salvador III. Journal of the Washington Academy of Sciences 14(4): 93–94. [*Zamia herrerae*]

Carabia, J. P. 1941. Contribuciones al estudio de la flora Cubana. Gymnospermae. Caribbean Forester 2(2): 83–99. [*Zamia guggenheimiana*]

Carruthers, W. 1893. On *Cycas taiwaniana* sp. nov. and *C. seemannii.* Journal of Botany 31: 1–3, pls. 330–331.

Chamberlain, C. J. 1912. Two species of *Bowenia.* Botanical Gazette 54: 419–423. [*B. serrulata*]

Chamberlain, C. J. 1919. The Living Cycads. Chicago: University of Chicago Press. Reprinted in 1965 at New York: Hafner.

Chamberlain, C. J. 1926. Two new species of *Zamia.* Botanical Gazette 81: 218–227. [*Z. monticola, Z. sylvatica*]

Chang, H. T., & Y. C. Zhong. 1997. New *Cycas* from Guangxi. Acta Scientiarum Naturalium Universitatis Sunyatseni 36(3): 67–71. [*C. longlinensis, C. multifida, C. shiwandashanica, C. xilingensis*]

Chang, H. T., Y. C. Zhong, Y. Y. Huang, H. X. Zheng & Z. F. Lu. 1998. Additions to the cycadaceous flora of China. Acta Scientiarum Naturalium Universitatis Sunyatseni 37: 6–8. [*Cycas acuminatissima, C. brevipinnata, C. longiconifera, C. palmatifida, C. septemsperma*]

Chavez, V. M., R. E. Litz & K. Norstog. 1992. *In vitro* morphogenesis of *Ceratozamia hildae* and *C. mexicana* from megagametophytes and zygotic embryos. Plant Cell, Tissue, and Organ Culture 30: 93–98.

Chemnick, J., & T. J. Gregory. 1995. A new species of *Ceratozamia* (Zamiaceae) from Oaxaca, Mexico, with comments on distribution, habitat, and relationships. Phytologia 79(1): 51–57. [*C. whitelockiana*]

Chemnick, J., T. J. Gregory & S. Salas-Morales. 1998a (as "1997"). A revision of *Dioon tomasellii* (Zamiaceae) from western Mexico, a range extension of *D. merolae,* and clarification of *D. purpusii.* Phytologia 83(1): 1–6. [*D. sonorense*]

Chemnick, J., T. J. Gregory & S. Salas-Morales. 1998b (as "1997"). *Ceratozamia mixeorum* (Zamiaceae), a new species of *Ceratozamia* from Oaxaca, Mexico, with comments on distribution, habitat, and species relationships. Phytologia 83(1): 47–52.

Chen, C. J., & S. Y. Yang. 1994a. *Cycas multipinnata,* a remarkable new cycad from China. Acta Phytotaxonomica Sinica 32(3): 239.

Chen, C. J., & S. Y. Yang. 1994b. Supplementary description of *Cycas multipinnata.* Acta Phytotaxonomica Sinica 32(5): 480–481.

Chen, C. J., & P. Yun. 1995. A new taxa [sic] of *Cycas* (Cycadaceae) in Yunnan. Acta Botanica Yunnanica 17(4): 400. [*C. pectinata* subsp. *manhaoensis*]

C. Y. Cheng, W. C. Cheng & L. K. Fu. 1975. *Cycas szechuanensis* sp. nov. and *Cycas hainanensis.* Acta Phytotaxonomica Sinica 13(4): 81–82.

Chirgwin, S. K. 1993. *Cycas conferta.* Journal of the Adelaide Botanic Garden 15: 147–148.

Chirgwin, S. K., & K. D. Hill. 1996. A taxonomic revision of the genus *Cycas* (Cycadaceae) in Australia. Telopea 7(1): 1–63. [*C. arnhemica* subsp. *muninga, C. maconochiei*]

Claassen, I. 1993. "Fishtail" *Encephalartos transvenosus.* Encephalartos 35: 20–21.

Craib, W. G. 1912. Contributions to the flora of Siam II. List of Siamese plants, with descriptions of new species. Bulletin of Miscellaneous Information, Royal Gardens, Kew 1912: 434–435. [*Cycas immersa*]

Dalzell, C. 2002. *Encephalartos woodii*: propagation from excised leaves, *in* The Biology, Structure, and Systematics of the Cycadales: Proceedings of Cycad 99, the Fifth International Conference on Cycad Biology. Memoirs of the New York Botanical Garden 87 (D. W. Stevenson, editor).

Dammer, U. 1906. Cycadaceae, *in* E. Ule, Beiträge zur Flora der Hylaea nach den Sammlungen von Ule's Amazonas-Expedition. Verhandlungen des Botanischen Vereins der Provinz Brandenburg 48: 117–118. [*Zamia ulei*]

de Candolle, A. 1868. Cycadaceae, *in* Prodromus Systematis Naturalis Regni Vegetabilis, pars 16(2). Paris: Treuttel & Würtz. [*Macrozamia macdonnellii, M. miquelii, M. oldfieldii, M. spiralis* var. *diplomera, Microcycas, M. calocoma, Zamia boliviana, Z. floridana, Z. loddigesii* var. *leiboldii, Z. multifoliolata, Z. spartea*]

de Laubenfels, D. J., & F. Adema. 1998. A taxonomic revision of the genera *Cycas* and *Epicycas* gen. nov. (Cycadceae). Blumea 43: 351–400. [*C. edentata, C. javana, Epicycas, E. elongata, E. lindstromii, E. micholitzii, E. miquelii, E. multipinnata, E. siamensis, E. tonkinensis*]

de Loureiro, P. 1793. Flora Cochinchinensis, second edition. Berlin: Haude & Spener. [*Cycas inermis*]

De Luca, P., & S. Sabato. 1979. *Dioon califanoi* (Zamiaceae), a new species from Mexico. Brittonia 31: 170–173.

De Luca, P., S. Sabato & M. Vázquez-Torres. 1980a. *Dioon caputoi* (Zamiaceae), a new species from Mexico. Brittonia 32: 43–46.

De Luca, P., A. Moretti, S. Sabato & M. Vázquez-Torres. 1980b. *Dioon rzedowskii* (Zamiaceae), a new species from Mexico. Brittonia 32: 225–229.

De Luca, P., S. Sabato & M. Vázquez-Torres. 1981a. *Dioon merolae* (Zamiaceae), a new species from Mexico. Brittonia 33: 179–185.

De Luca, P., S. Sabato & M. Vázquez-Torres. 1981b. *Dioon holmgrenii* (Zamiaceae), a new species from Mexico. Brittonia 33: 552–555.

De Luca, P., S. Sabato & M. Vázquez-Torres. 1982. Distribution and variation of *Dioon edule* (Zamiaceae). Brittonia 34: 355–362. [*D. edule* var. *angustifolium*]

De Luca, P., S. Sabato & M. Vázquez-Torres. 1984. *Dioon tomasellii* (Zamiaceae), a new species with two varieties from western Mexico. Brittonia 36: 223–227.

De Luca, P., D. W. Stevenson & A. Moretti. 1989. *Encephalartos* *sclavoi* De Luca, D. Stevenson, and Moretti (Zamiaceae), a new species from Tanzania. Delpinoa 29–30: 3–5.

Devred, R. 1959. Une Cycadacée nouvelle du Congo Belge: *Encephalartos marunguensis* Devred. Bulletin de la Société Royale de Botanique de Belgique 91: 103–108.

de Vriese, W. H. 1838. Nova species Cycadearum Africae australis. Tijdschrift voor Natuurlijke Geschiedenis en Physiologie 4(24): 409–425. [*Encephalartos brachyphyllus, E. elongatus, E. latifrons, E. spinulosus*]

De Wildeman, É. 1903. Études de la systematique et de géographie botanique sur la flore du Bas- et du Moyen-Congo. Annales du Musée du Congo Belge, Bot., sér. 5, 1(1): 1–80. [*Encephalartos laurentianus*]

De Wildeman, É., & T. Durand. 1900. Bulletin de la Société Royale de Botanique de Belgique 39(2): 80–82. [*Encephalartos lemarinelianus*]

Dietrich, A. 1851. Bericht über zwei neue Zamion, nebet Abbildung derselben. Allgemeine Gartenzeitung 19: 145–146. [*Zamia lindleyi, Z. skinneri*]

Dodson, C. H. 1994. The zamias of Ecuador. Cycad Newsletter 18(3): 2–5.

Dodson, C. H. 1998. A new species of *Zamia* (Zamiaceae) from Eucador. Novon 8(1): 12–14. [*Z. gentryi*]

Don, G. 1842. Notice of four new plants, discovered in the South Sea Islands by the late Mr. James Corson, surgeon. Gardener's Magazine and Register of Rural and Domestic Improvements 13: 371. [*Cycas corsoniana*]

Donnell Smith, J. 1903. Undescribed plants from Guatamala and other Central American republics XXIV. Botanical Gazette 35(1): 8, pl. 1. [*Zamia tuerckheimii*]

Ducke, A. 1915. Plantes nouvelles ou peu connues de la région Amazonienne. Archivios do Jardim Botânico do Rio de Janeiro 1: 5–59. [*Zamia lecointei*]

Ducke, A. 1922. Plantes nouvelles ou peu connues de la région Amazonienne 2. Archivios do Jardim Botânico do Rio de Janeiro 3: 19–20, pl. 11. [*Zamia cupatiensis, Z. obidensis*]

Dyer, R. A. 1951. *Encephalartos umbeluziensis.* Flowering Plants of Africa 28: pl. 1100.

Dyer, R. A. 1956. A new cycad from the Cape Province. Journal of South African Botany 22: 1–4. [*Encephalartos arenarius*]

Dyer, R. A. 1964. Cycadaceae. *Encephalartos inopinus.* Bothalia 8: 169–170.

Dyer, R. A. 1965a. New species and notes on type specimens of South African *Encephalartos.* Journal of South African Botany 31: 111–121. [*E. princeps, E. trispinosus*]

Dyer, R. A. 1965b. The cycads of southern Africa. Bothalia 8(4): 404–515.

Dyer, R. A. 1971. A further new species of cycad from the Transvaal. Bothalia 10(2): 379–383. [*Encephalartos cupidus*]

Dyer, R. A. 1972. A new species of *Encephalartos* from Swaziland. Bothalia 10(4): 539–546. [*E. heenanii*]

Dyer, R. A., & I. C. Verdoorn. 1951. *Encephalartos natalensis.* Bothalia 6: 205–211.

Dyer, R. A., & I. C. Verdoorn. 1969. *Encephalartos manikensis* and its near allies. Kirkia 7(1): 147–158. [*E. chimanimaniensis, E. concinnus, E. munchii, E. pterogonus*]

Eckenwalder, J. E. 1980. Taxonomy of the West Indian cycads. Journal of the Arnold Arboretum 61: 701–722. [*Zamia pumila* subsp. *pygmaea*]

Ecklon, C. F., & C. L. P. Zeyher. 1833. Nachricht von den Pflanzen, welche Herr Edion aus Sud-Afrika mit gebracht hat. Allgemeine Gartenzeitung 1: 158. [*Zamia lehmanniana*]

Eggeling, W. J. 1940. The Indigenous Trees of the Uganda Protectorate. Entebbe, Uganda: Government Printer.

Eichler, A. W. 1863. Cycadeae et Coniferae, *in* C. Martius, Flora Brasiliensis, volume 4(1). [*Zamia parasitica, Z. poeppigiana*]

Faden, R. B., & H. J. Beentje. 1989. *Encephalartos kisambo,* a new cycad from Kenya, with a note on *E. tegulaneus.* Utafiti 2(1): 7–10.

Fitzgerald, W. V. 1918. The botany of the Kimberleys. Journal and Proceedings of the Royal Society of Western Australia 3: 102–224. [*Cycas furfuracea*]

Forster, P. I. 1995. *Cycas desolata,* a new species from north Queensland. Austrobaileya 4(3): 345–350.

Forster, P. I., & D. L. Jones. 1994. Seven new species of *Macrozamia* Miq. (Zamiaceae section *Parzazamia*) from Queensland. Austrobaileya 4(2): 269–288. [*M. conferta, M. cranei, M. crassifolia, M. machinii, M. occidua, M. parcifolia, M. viridis*]

Gardner, C. A. 1923. Cycadaceae, *in* Botanical notes of the Kimberley. Bulletin, Woods and Forests Department, Western Australia 32: 30–32. [*Cycas basaltica, C. lane-poolei*]

Gardner, C. A. 1930. Enumeratio Plantarum Australiae Occidentalis. Perth: Government Printer. [*Macrozamia dyeri, M. riedlei*]

Gardner, C. A. 1956. *In* C. A. Gardner & H. W. Bennetts, The Toxic Plants of Western Australia. Perth: West Australian Newspapers, Periodicals Division.

Gaudichand-Beaupré, C. 1829. Botanique, pp. 436–441 *in* L. de Freycinet, Voyage Autour du Monde. Paris: Billet-ainé. [*Cycas riedlei, C. thouarsii, C. undulata*]

Giddy, C. 1984. Cycads of South Africa, second edition. Cape Town: C. Struik.

Gilliland, H. B. 1938. Gymnosperms, *in* Notes on the flora of Rhodesian Manicaland. I. Journal of South African Botany 4: 153–156. [*Encephartos gratus* var. *manikensis*]

Gilliland, H. B. 1939. A note on the Rhodesian cycad. Proceedings and Transactions of the Rhodesia Scientific Association 37: 133–134. [*Encephartos manikensis*]

Gómez, L. D. 1982. Plantae Mesoamericanae novae II. Phytologia 50(6): 401–404. [*Zamia fairchildiana, Z. pseudomonticola*]

Goode, D. 1989. Cycads of Africa. Cape Town: Struik, Winchester.

Griffith, W. 1854. Cycadaceae, *in* Notulae ad Plantas Asiaticas, volume 4. Calcutta: C. A. Serrao. [*Cycas jenkinsiana, C. macrocarpa*]

Guan, Z. T., & G. D. Tao. 1995. A preliminary report of new cycad from Yunnan. Sichuan Forestry Survey and Design 1995(4): 1–2. [*Cycas diannanensis*]

Haines, H. H. 1924. The Botany of Bihar and Orissa, volume 6. London: Adlard. [*Cycas circinalis* var. *orixensis*]

Hall, A. V., M. De Winter, B. De Winter & S. A. M. van Oosterhout. 1980. Threatened Plants of Southern Africa. South African National Scientific Programmes Report, no. 45. Pretoria: Cooperative Scientific Programmes, Council for Scientific and Industrial Research.

Heenan, D. 1977. Some observations on the cycads of central Africa. Botanical Journal of the Linnean Society 74(3): 279–288.

Henderson, M. R. 1945. Materials for a revision of the South African species of *Encephalartos.* Journal of South African Botany 11(1): 5–64.

Heynhold, G. 1841. Nomenclator Botanicus Hortensis, volume 2. Dresden & Leipzig: Arnold. [*Zamia elongata, Z. spinulosa*]

Hiep, N. T., & J. E. Vidal. 1996. Gymnospermae, Cycadaceae, pp. 6–23 *in* Flore du Cambodge, du Laos et du Vietnam, volume 28 (P. Morat, editor). Paris: Muséum National d'Histoire Naturelle.

Hill, K. D. 1992. A preliminary account of *Cycas* (Cycadaceae) in Queensland. Telopea 5: 177–206. [*C. brunnea, C. couttsiana, C. megacarpa, C. ophiolitica, C. platyphylla, C. silvestris*]

Hill, K. D. 1993. *Cycas arenicola* (Cycadaceae), a new species from the Northern Territory of Australia. Telopea 5: 419–422.

Hill, K. D. 1994a. The *Cycas media* group (Cycadaceae) in New Guinea. Australian Systematic Botany 7: 527–541. [*C. campestris*]

Hill, K. D. 1994b. The *Cycas rumphii* complex (Cycadaceae) in New Guinea and the western Pacific. Australian Systematic Botany 78: 543–567. [*C. apoa, C. bougainvilleana, C. micronesica*]

Hill, K. D. 1994c. Three new species of *Cycas* from the Northern Territory of Australia. Telopea 5(4): 693–701. [*C. arnhemica, C. canalis, C. canalis* subsp. *carinata, C. orientis*]

Hill, K. D. 1995. Taxonomic changes in the Australian cycads, pp. 193–223 *in* Proceedings of the Third International Conference on Cycad Biology (P. Vorster, editor). Stellenbosch: Cycad Society of South Africa. [*Cycas curranii, C. simplicipinna*]

Hill, K. D. 1996. A taxonomic revision of the genus *Cycas* (Cycadaceae) in Australia. Telopea 7(1): 1–64. [*C. arnhemica* subsp. *natja, C. badensis, C. maconochiei* subspp. *lanata, viridis, C. media* subspp. *banksii, ensata, C. semota, C. tuckeri, C. xipholepis, C. yorkiana*]

Hill, K. D. 1999a. *Cycas falcata* (Cycadaceae), a new species from Sulawesi, Indonesia. Kew Bulletin 54(1): 209–213.

Hill, K. D. 1999b. The genus *Cycas* (Cycadaceae) in Thailand. Brittonia 51(1): 48–73. [*C. chamaoensis, C. clivicola, C. clivicola* subsp. *lutea, C.litoralis, C. nongnoochiae*]

Hill, K. D., & S. L. Yang. 1999. The genus *Cycas* (Cycadaceae) in Thailand. Brittonia 51(1): 48–73. [*C. tansachana*]

Hill, K. D., D. L. Jones & P. I. Forster. 1998. Cycadophyta, *in* Flora of Australia, volume 48: Ferns, Gymnosperms and Allied Groups. Collingwood, Victoria: Australian Biological Resources Study & C.S.I.R.O. [*Macrozamia cardiacensis, M. concinna, M. elegans, M. glaucophylla, M. humilis, M. longispina, M. montana, M. polymorpha, M. reducta*]

Hill, K. D., H. T. Nguyen, L. K. Phan & S. L. Yang. 2002. The genus *Cycas* in Vietnam, *in* The Biology, Structure, and Systematics of the Cycadales: Proceedings of Cycad 99, the Fifth International Conference on Cycad Biology. Memoirs of the New York Botanical Garden 87 (D. W. Stevenson, editor). [*C. aculeata, C. bifida, C. brachycantha, C. collina, C. condaoensis, C. dolichophylla, C. hoabinhensis, C. pachypoda, C. tropophylla*]

Hill, W. 1865. Gardeners' Chronicle 1865(47): 1107. [*Catakidozamia, C. hopei*]

Hill, W., & F. Mueller. 1859. Fragmenta Phytographiae Australiae, volume 1. Melbourne: Ferres. [*Macrozamia pauliguilielmi*]

Hooker, J. D. 1863. *Bowenia, B. spectabilis.* Curtis's Botanical Magazine 89: pls. 5398, 6008.

Hooker, J. D. 1872. *Macrozamia corallipes.* Curtis's Botanical Magazine 98: pl. 5943.

Hooker, W. J. 1863. *Encephalartos horridus* var. *trispinosa.* Curtis's Botanical Magazine 89: pl. 5371.

Hurter, P. J. H. 1995. Two newly described cycads from Africa. Phytologia 78(6): 409–416. [*Encephalartos nubimontanus, E. whitelockii*]

Hurter, P. J. H. 2002. *Encephalartos relictus* (Zamiaceae): a newly described species from southern Africa, *in* The Biology, Structure, and Systematics of the Cycadales: Proceedings of Cycad 99, the Fifth International Conference on Cycad Biology. Memoirs of the New York Botanical Garden 87 (D. W. Stevenson, editor).

Hurter, P. J. H., & H. F. Glen. 1995. *Encephalartos equatorialis* (Zamiaceae), a newly described species from tropical Africa. South African Journal of Botany 61(4): 226–229.

Hurter, P. J. H., & H. F. Glen. 1996. *Encephalartos hirsutus* (Zamiaceae), a newly described species from South Africa. South African Journal of Botany 62(1): 46–48.

Hutchinson, J. 1932. Notes on the flora of southern Africa. Bulletin of Miscellaneous Information, Royal Gardens, Kew 1932: 510–512. [*Encephalartos kosiensis*]

Hutchinson, J., & G. Rattray. 1933. Cycadaceae, pp. 24–44 *in* Flora Capensis (A. W. Hill, editor), volume 5 (section 2, supplement). London: Reeve.

Jacquin, N. J. 1791. Collectanea ad Botanicam Vindbonae, volume 3. Vienna: Wappler. [*Zamia angustifolia*]

Jacquin, N. J. 1801. Fragmenta Botanica. Vienna: Schmidt. [*Zamia cycadifolia, Z. horrida, Z. longifolia*]

Johnson, L. A. S. 1959. The families of cycads and the Zamiaceae of Australia. Proceedings of the Linnean Society of New South Wales 84: 64–117. [*Macrozamia communis, M. diplomera, M. lucida, M. pauli-guilielmi* subspp. *flexuosa, plurinervia, M. stenomera*]

Jones, D. L. 1991. Notes on *Macrozamia* Miq. (Zamiaceae) in Queensland with the description of two new species in section *Parazamia* (Miq.) Miq. Austrobaileya 3: 481–487. [*M. fearnsidei, M. lomandroides, M. plurinervia*]

Jones, D. L. 1993. Cycads of the World. Chatswood, New South Wales: Reed, and Washington, D.C.: Smithsonian Institution Press.

Jones, D. L., & Hill, K. D. 1992. *Macrozamia johnsonii,* a new species of *Macrozamia* section *Macrozamia* (Zamiaceae) from northern New South Wales. Telopea 5(1) 31–34.

Jones, S., & W. J. Wynants. 1997. *Encephalartos macrostrobilus* (Zamiaceae), a new cycad species from northern Uganda. Encephalartos 50: 13–16.

Kanehira, R. 1938. On the Micronesian species of *Cycas.* Journal of Japanese Botany 14: 579–588. [*C. rumphii* formae *palauica, papuana, seemannii, undulata*]

Kunze, G. 1836. Acotyledonearum Africae australioris recensio nova. Linnaea 10: 481–556. [*"Lomaria coriacea"*]

Kunze, G. 1839. Additamentum enumerationis filicum Mexicanarum, partim A. B. Schiedeo, partim a Cl. Car. Ehrenbergio aliisque collectarum. Linnaea 13: 152. [*Lomaria eriopus*]

Lan, K., & R. F. Zhou. 1983. A new species of *Cycas* Linn. from Guizhou province. Acta Phytotaxonomica Sinica 21: 209–210. [*C. guizhouensis*]

Landry, G. P., & M. C. Wilson. 1979. A new species of *Ceratozamia* (Cycadaceae) from San Luis Potosí. Brittonia 31: 422–424. [*C. hildae*]

Lauterbach, C. A. G. 1900. Cycadaceae, *in* Die Flora der Deutschen Schutzgebiete in der Südsee (K. Schumann & C. Lauterbach, editors). Leipzig: Gebrüder Borntraeger. [*Cycas schumanniana*]

Lavranos, J. J., & D. L. Goode. 1985. *Encephalartos turneri* (Cycadaceae), a new species from Mozambique. Garcia de Orta, Série de Botânica 7(1–2): 11–14.

Lavranos, J. J., & D. L. Goode. 1988. Notes on southern African Cycadales. Bulletin du Jardin Botanique National de Belgique 58: 219–224. [*Encephalartos dolomiticus, E. dyerianus, E. eugene-maraisii* subsp. *middelburgensis*]

Lavranos, J. J., & D. L. Goode. 1989. Notes on southern African Cycadales 2. Durban Museum Novitates 14(8): 153–156. [*Encephalartos cerinus*]

Leandri, J. D. 1931. Cycadaceae, *in* M. H. Lecompte, Flore Générale de l'Indo-Chine, volume 5(10). Paris: Masson. [*Cycas chevaleri, C. pectinata* var. *elongata*]

Lehmann, J. G. C. 1834. De plantis Cycadeis praesertim Africae australis. Novarum et Minus Cognitarum Stirpium Pugillus 6: 1–16, pls. 1–5. Hamburg: Meissner. [*Encephalartos, E. altensteinii, E. caffer, E. cycadifolius, E. friderici-guilielmi, E. horridus, E. lehmannii, E. longifolius, E. pungens, E. spiralis*]

Lehmann, J. G. C. 1844. Novarum et Minus Cognitarum Stirpium Pugillus 8: 31. Hamburg: Meissner. [*Macrozamia preissii*]

Lemaire, C. 1855. *Dioon edule* Lindley. Illustration Horticole 2: 91–94. [*D. aculeatum*]

Lemaire, C. 1863. D'un cone vale du *Dion edule.* Illustration Horticole 10: 3–4. [*D. strobilaceum*]

Lemaire, C. 1868a. *Encephalartos ghellinckii.* Illustration Horticole 15: 79–81, pl. 567.

Lemaire, C. 1868b. *Encephalartos villosus.* Illustration Horticole 15: 69, pl. 557.

Linden, J. J. 1873. Catalogue des Plantes Nouvelles, no. 90. Ghent: J. Linden. [*Zamia roezlii*]

Linden, J. J., & E. Rodigas. 1885. Illustration Horticole 32: 27, pl. 547. [*Zamia tonkinensis*]

Linden, J. J., & E. Rodigas. 1886. Novita orticole. Bullettino della Società Tosccana di Orticultura. Florence 11(9): 279–280. [*Cycas tonkinensis*]

Lindley, J. 1843. *Dion edule.* Edwards's Botanical Register 29: 59–60. [*Dioon, D. edule*]

Lindstrom, A., & K. D. Hill. 2002. New species and new records of *Cycas* (Cycadaceae) from Thailand. Brittonia. [*Cycas elephantipes, C. petraea*]

Linnaeus, C. 1753. Species Plantarum, volume 2. Stockholm: Laurentius Salvius. [*Cycas, C. circinalis*]

Linnaeus, C. 1763. Species Plantarum, second edition, volume 2. Stockholm: Laurentius Salvius. [*Zamia, Z. pumila*]

Litz, R. E., P. A. Moon & V. M. Chavez. 1995. Somatic embryogenesis from leaf callus derived from mature trees of the cycad *Ceratozamia hildae* (Gymnospermae). Plant Cell, Tissue, and Organ Culture 40: 25–31.

Liu, N. 1998. A new species of the genus *Cycas* from Hainan Island, China. Acta Phytotaxinomica Sinica 36(6): 552–554. [*C. changjiangensis*]

Loddiges, G. 1843. Catalogue of Plants, nos. 168, 177, 187. [*Zamia occidentalis*]

Lundell, C. L. 1939. Studies of Mexican and Central American plants—VII. Lloydia 2: 73–76. [*Ceratozamia matudae*]

Maconochie, J. R. 1978. Two new species of *Cycas* from northern Australia. Journal of the Adelaide Botanic Garden 1(3): 175–178. [*C. calcicola, C. pruinosa*]

Maconochie, J. R. 1980. Key to *Cycas, in* Ferns, Fern Allies and Conifers of Australia (H. T. Clifford & J. Constantine). St. Lucia: University of Queensland Press.

Maiden, J. H., & E. Betche. 1916. A census of New South Wales plants. Sydney: W. A. Gullick. [*Macrozamia spiralis* vars. *cylindrica, fawcettii, flexuosa, heteromera*]

Malaisse, F. 1969. *Encephalartos schmitzii* Malaisse, Cycadacée nouvelle du Congo-Kinshasa. Bulletin du Jardin Botanique National de Belgique 39: 401–406.

Malaisse, F., J. P. Sclavo & I. Turner. 1990. Zamiaceae, a new family for Zambia. Memoirs of the New York Botanical Garden 57: 162–168.

Malaisse, F., J. P. Sclavo & C. Crosiers. 1992. Recherches sur les *Encephalartos* (Zamiaceae) d'Afrique centrale. Annales de Gembloux 98: 153–157. [*E. delucanus, E. schaijesii*]

Marloth, R. 1913. Cycadales, *in* The Flora of South Africa, volume 1. Cape Town: Darter Bros. [*Stangeria paradoxa* vars. *katzeri, schizodon*]

Masters, M. T. 1875. *Macrozamia plumosa* hort. Gardeners' Chronicle 3: 562.

Masters, M. T. 1877. Home correspondence. *Macrozamia mackenzii.* Gardeners' Chronicle 7(178): 665.

Masters, M. T. 1878. New garden plants. Gardeners' Chronicle 10(261): 810. [*Zamia amplifolia*]

Masters, M. T. 1893. *Dioon pectinatum.* Gardeners' Chronicle 17(June): 718–719.

Medellin-Leal, F. 1963. A new species of *Ceratozamia* from San Luis Potosí. Brittonia 15: 175–176. [*C. zaragozae*]

Melville, R. 1957. *Encephalartos* in central Africa. Kew Bulletin 12: 237–257. [*E. bubalinus, E. hildebrandtii* var. *dentatus, E. tegulaneus*]

Melville, R. 1958. Gymnospermae: Cycadaceae, *in* Flora of Tropical East Africa. London: Crown Agents.

Merrill, E. D. 1936. A new Philippine species of *Cycas.* Philippine Journal of Science 60: 233–239. [*C. wadei*]

Messeri, A. 1927. Nuovo Giornale Botanico Italiano, new ser. 34: 324, 327. [*Cycas revoluta* var. *robusta*]

Millspaugh, C. F. 1900. Plantai utowanae. Publications of the Field Columbian Museum, Botanical Series 2(1): 23. [*Zamia allison-armourii*]

Miquel, F. A. W. 1838. Note sur l'*Encephalartos horridus* Lehm. Et sur ses différentes formes. Annales des Sciences Naturelles Botanique, sér. 2, 10: 366–369. [*E. horridus* f. *latifrons*]

Miquel, F. A. W. 1839. Mélanges botaniques. Bulletin des Sciences Physiques et Naturelles en Néerlande 1839: 37–48. [*Cycas celebica, C. rumphii*]

Miquel, F. A. W. 1840. Commentarii phytographici, quibus varia rei herbariae capita illustrantur. Fasciculus III. Sylloge plantarum novarum vel minus cognitarum ex ordinibus Araliacearum, Cactearum, Hypoxidearum, Cycadearum et Urticacearum. Leiden: S. & J. Luchtmans. [*Cycas glauca, C. madagascariensis, C. rumphii* var. *timorensis*]

Miquel, F. A. W. 1842. Monographia Cycadearum. Utrecht: R. Natan. [*Cycas circinalis* var. *javana, C. revoluta* var. *planifolia, C. wallichii, Encephalartos horridus* var. *latifrons, E. mauritanus, Macrozamia, M. fraseri, M. spiralis*]

Miquel, F. A. W. 1843. De Cycadeis Loddigesianus. Tijdschrift voor Natuurlijke Geschiedenis en Physiologie 10(1): 68–74. Abstract: Description d'une nouvelle espèce de *Zamia.* Annales des Sciences Naturelles, Botanique, sér. 2, 19: 316–317. [*Z. loddigesii*]

Miquel, F. A. W. 1844a. Genera et species Cycadearum viventium. Linnaea 17(6): 675–744. [*Zamia kickxii*]

Miquel, F. A. W. 1844b. Addenda ad synopsin Cycadeaerum viventium. Linnaea 18(1): 96–98. [*Zamia maclenii*]

Miquel, F. A. W. 1846. *In* J. Lindley, The Vegetable Kingdom. London: Bradbury & Evans. [*Encephalartos lehmannii* var. *spinulosus*]

Miquel, F. A. W. 1847. Collectanea nova ad Cycadearum cognitionem. Linnaea 19(4): 411–430, pls. 1–7. [*Zamia fischeri, Z. leiboldii*]

Miquel, F. A. W. 1848. Over eenige nieuwe of zeldzame Cycadeën in den Hortus Botanicus te Amsterdam, derde gedeelte. Tijdschrift voor de Wis- en Natuurkundige Wetenschappen 1(4): 197–208. [*Ceratozamia robusta, Cycas revoluta* vars. *brevifrons, inermis, Dioon angustifolium, D. imbricatum, Zamia muricata* var. *picta*]

Miquel, F. A. W. 1849. Epicrisis systematis Cycadearum. Tijdschrift voor de Wis- en Natuurkundige Wetenschappen 2(4): 280–302. [*Ceratozamia latifolia*]

Miquel, F. A. W. 1851. Cycadeae quaedam Americanae, partim novae. Verhandelingen der Eerste Klasse van het Koninklijk Nederlandsch Instituut van Wetenschappen, Letterkunde en Schoone Kunsten te Amsterdam, ser. 3, 4: 181–188. [*Zamia stricta*]

Miquel, F. A. W. 1852. Sur une espèce nouvelle de *Zamia* des Indes Occidentales, introduite dans l'éstablissement Van Houtte, à Gand. Flore des Serres et des Jardins de l'Europe 7: 141–142. [*Zamia* sect. *Microcyas, Z. angustissima, Z. calocoma*]

Miquel, F. A. W. 1861. Prodromus Systematis Cycadearum. Utrecht: C. G. van der Post. [*Zamia yatesii*]

Miquel, F. A. W. 1863. Over de Cycadeën in Nieuw-Holland. Verslagen en Mededeelingen van de Afdeeling Natuurkunde; Koninklijke Akademie van Wetenschappen 15: 362–376. [*Cycas gracilis, C. siamensis, Encephalartos* sect. *Lepidozamia, E. fraseri, E. macdonnellii, E. oldfieldii, E. spiralis* var. *major*]

Miquel, F. A. W. 1868. Nouveaux matériaux pour servir à la connaissance des Cycadées, première–troisième parties, quatrième–cinquième parties. Archives Néerlandaises des Sciences Exactes et Naturelles 3(3): 193–254, 3(5): 403–427. [*Cycas armstrongii, Encephalartos barteri, Macrozamia* sect. *Lepidozamia, M. macleayi, M. peroffskyana*]

Miquel, F. A. W. 1869. Nieuwe bijdragen tot de kennis der Cycadeen, zesde gedeelte. Verslagen en Mededeelingen van de Afdeeling Natuurkunde; Koninklijke Akademie van Wetenschappen, ser. 2, 4: 23–57. [*Zamia verschaffeltii*]

Moore, C. 1884. Notes on the genus *Macrozamia.* Journal and Proceedings of the Royal Society of New South Wales 17: 115–122. [*M. cylindrica, M. fawcettii, M. flexuosa, M. heteromera, M. heteromera* vars. *glauca, tenuifolia, M. secunda*]

Moore, C., & Mueller, F. 1858. Fragmenta Phytographiae Australiae, volume 1. Melbourne: Ferres. [*Macrozamia denisonii*]

Moore, T. 1853. List of Mr. Plan's Natal ferns. Hooker's Journal of Botany and Kew Garden Miscellany 5: 228–229. [*Stangeria, S. paradoxa*]

Moore, T. 1878. The new plants of 1877. Gardeners' Chronicle 9(210): 11. [*Bowenia spectabilis* [var.] *serrulata*]

Moretti, A., P. De Luca, J. P. Sclavo & D. W. Stevenson. 1989. *Encephalartos voiensis* (Zamiaceae), a new East Central African species in the *E. hildebrandtii* complex. Annals of the Missouri Botanical Garden 76: 934–938.

Moya, E., M. de Boyrie, K. Krestenses & J. M. Groggin. 1957. *Zamia* starch in Santo Domingo: a contribution to the ethnobotany of the Dominican Republic. Florida Anthropology, Florida State University, 10(3–4).

Mueller, F. 1859. Remarks on Australian Cycadeae. Quarterly Journal of the Pharmaceutical Society of Victoria 2: 90. [*Encephalartos denisonii, E. preissii*]

Mueller, F. 1862. Fragmenta Phytographiae Australiae, volume 3. Melbourne. Melbourne: Ferres. [*Encephalartos miquelii*]

Mueller, F. 1866. Fragmenta Phytographiae Australiae, volume 5. Melbourne: Ferres. [*Encephalartos spiralis* var. *diplomera*]

Mueller, F. 1874. Fragmenta Phytographiae Australiae, volume 8. Melbourne: Ferres. [*Cycas normanbyana*]

Mueller, F. 1876a. Fragmenta Phytographiae Australiae, volume 10. Melbourne: Ferres. [*Cycas cairnsiana*]

Mueller, F. 1876b. Descriptive Notes on Papuan Plants, part 1. Melbourne. [*Cycas papuana*]

Mueller, F. 1881a (March). Notes on a hitherto undefined species of *Encepharlartos*. Australasian Chemist and Druggist, Supplement 4: 84–85. [*Macrozamia moorei*]

Mueller, F. 1881b (August). Fragmenta Phytographiae Australiae, volume 11. Melbourne: Ferres. [*Encephalartos moorei*]

Mueller, F. 1882. Notes on a hitherto undefined species of *Cycas.* Australasian Chemist and Druggist, page 16. [*C. kennedyana*]

Mueller, F. 1885a. Succinct notes on some plants from New Guinea. Victorian Naturalist 2(2): 18–19. [*Cycas scratchleyana*]

Mueller, F. 1885b. Description of new cycadeous plants from south-western Australia. Botanisches Centralblatt 23: 225–226. [*Encephalartos dyeri*]

Newton, L. E. 1978. A new cycad subspecies from Nigeria. Botanical Journal of the Linnean Society 77: 125–129. [*Encephalartos barteri* subsp. *allochrous*]

Norstog, K. J., & T. J. Nicholls. 1997. The Biology of the Cycads. Ithaca, New York: Cornell University Press.

Osborne, R. 1989. Cycad pollen survives ultra-low temperature. Encephalartos 17: 25.

Osborne, R. 1992. Artificial propagation project: results of a recent survey. Encephalartos 32: 23–24.

Osborne, R., & H. Baijnath. 1995. Morphometric analysis of vegetative characters of *Encephalartos woodii, E. natalensis* and an apparent intermediate, pp. 241–244 *in* Proceedings of the Third International Conference on Cycad Biology (P. Vorster, editor). Stellenbosch: Cycad Society of South Africa.

Osborne, R., & C. Dalzell. 1996. Potential propagation of *Encephalartos woodii* from excised leaves. Encephalartos 45: 16–17.

Osborne, R., P. J. Robbertse & M. I. Claassen. 1991. The longevity of cycad pollen. Encephalartos 28: 10–13.

Osborne, R., A. Grove, P. Oh, T. J. Mabry, J. C. Ng & A. A. Seawright. 1994. The magical and medicinal usage of *Stangeria eriopus* in South Africa. Journal of Ethnopharmacology 43: 67–72.

Pant, D. D., & D. D. Nautiyal. 1963. On the anatomical structure of the pinnae of some species of *Cycas* L. (Cycadaceae). Current Science 32(5): 232–234.

Parham, J. W. 1948. The Botanical Gardens, Suva. Agricultural Journal (Suva) 19: 88–105. [*Cycas rumphii* var. *seemannii*]

Pearson, H. H. W. 1916. The Kirstenbosch cycads. Journal of the Botanical Society, part 2.

Pérez-Farrera, M. A., A. Vovides & C. Iglesias. 1999. A new species of *Ceratozamia* (Zamiaceae, Cycadales) from Chiapas, Mexico. Novon 9(3): 410–413. [*C. alvarezii*]

Pérez-Farrera, M. A., A. Vovides & C. Iglesias. 2001. New species of *Ceratozamia* (Zamiaceae) from Chiapas, Mexico. Botanical Journal of the Linnean Society. [*C. mirandae, C. zoquorum*]

Prain, D. 1909. *Encephalartos barteri.* Curtis's Botanical Magazine 135: pl. 8232.

Prain, D. 1916. *Encephalartos gratus.* Bulletin of Miscellaneous Information, Royal Gardens, Kew 1916: 181–182.

Prain, D. 1917. Cycadaceae, *in* Flora of Tropical Africa, volume 6(2). London: L. Reeve.

Prenleloup, L.-A. 1872. Remarques sur quelques zamias et leurs products. Bulletin de la Societe Vaudoise des Sciences Naturelles 11: 277–278. [*Zamia latifoliolata*]

Regel, E. A. 1857. Zwei [sic] neue Cycadeen, die im Botanischen Garten zu Petersburg kultivirt werden, nebst Beiträge zu Kenntniss dieser Familie. Bulletin de la Société Impériale des Naturalistes de Moscou 30(1): 163–191. [*Ceratozamia kuesteriana, Lepidozamia, L. peroffskyana, Zamia loddigesii* vars. *angustifolia, obtusifolia*]

Regel, E. A. 1863. *Cycas riuminiana.* Gartenflora 12: 16–17.

Regel, E. A. 1874. *Stangeria katzeri.* Gartenflora 23: 163–165, pl. 798.

Regel, E. A. 1876a. Die Cycadeen deren Gattungen und Arten. Gartenflora 25: 3–6. [*Aulacophyllum, A. lindenii, A. montanum, A. roezlii, A. skinneri, A. wallisii, Lepidozamia denisonii, L. hopei, Macrozamia tridentata*]

Regel, E. A. 1876b. Cycadearum generum specierumque revisio. Trudy Imperatorskago S.-Peterburgskago Botanicheskago Sada 4(2–4): 273–320. [*Cycas gracilis* vars. *glauca, viridis, Macrozamia tridentata* var. *oblongifolia, Zamia leiboldii* vars. *angustifolia, latifolia, Z. manicata*]

Resslar, P. M. 2002. Genotypic variation in the *in vitro* formation of callus on the petioles of *Stangeria, in* The Biology, Structure, and Systematics of the Cycadales: Proceedings of Cycad 99, the Fifth International Conference on Cycad Biology. Memoirs of the New York Botanical Garden 87 (D. W. Stevenson, editor).

Robyns, W. 1948. Gymnospermae. I. Cycadaceae, *in* Flore du Congo Belge et du Ruanda-Urundi. Brussels: I.N.É.A.C.

Rose, J. N. 1909. Studies of Mexican & Central American plants no. 6; a new species of *Dioon.* Contributions from the United States National Herbarium 12(7): 260–261. [*D. purpusii*]

Roxburgh, W. 1832. Flora Indica, volume 3. Serampore: Thacker. [*C. sphaerica*]

Rzedowski, J. 1978. Vegetación de México. México: Limusa.

Sacks, O. 1997. The Island of the Colorblind and, Cycad Island. New York: Alfred A. Knopf.

Salisbury, R. A. 1796. Prodromus Stirpium in Horto ad Chapel Allerton Vigentium. London. [*Zamia spiralis*]

Sander, F. 1908. New plants exhibited by Messrs. Sander & Sons of St. Albans and Bruges, at the centenary exhibition of the Ghent Botanical and Horticultural Society. Gardeners' Chronicle: 257. [*Encephalartos woodii*]

Schultes, R. E. 1953. Notes on *Zamia* in the Colombian Amazonia. Mutisia 15: 16. [*Z. jirijirimensis*]

Schultes, R. E. 1958. Plantae Austroamericanae X. Botanical Museum Leaflets 18(4): 114–117. [*Zamia madida*]

Schuster, J. 1932. Cycadaceae, *in* Das Pflanzenreich, IV, 1 (Heft 99). Berlin: Wilhelm Engelmann. [*Cycas circinalis* formae *glauca, graminea, maritima, undulata,* subspp. *madagascariensis, papuana, seemannii,* vars. *beddomei, curranii, pectinata, scratchleyana, C. media* vars. *basaltica, furfuracea, C. nathorstii, C. recurvata, C. revoluta* var. *taiwaniana, C. rumphii* subsp. *normanbyana,* var. *subinclusa, C. siamensis* subspp. *balansae, inermis, C. sundaica, Macrozamia* sect. *Monoorientales, Macrozamia denisonii* var. *hopei, M. heteromera* f. *harmsii,* vars. *dicranophylloides, tenuifolia, M. preissii* subsp. *dyeri, M. tridentata* formae *dielsii, diplomera, milkaui, oblongifolia, wallsendensis,* subspp. *cylindrica, mountperriensis,* var. *mackenzii, Stangeria paradoxa* f. *schizodon, Zamia kalbreyeri, Z. loddigesii* vars. *cycadifolia, latifolia, longifolia, spartea*]

Schutzman, B. 1984. A new species of *Zamia* L. (Zamiaceae, Cycadales) from Chiapas, Mexico. Phytologia 55: 299–304. [*Z. splendens*]

Schutzman, B. 1989. A new species of *Zamia* from Honduras. Systematic Botany 14(2): 214–219. [*Z. standleyi*]

Schutzman, B., & A. P. Vovides. 1998. A new *Zamia* (Zamiaceae, Cycadales) from eastern Chiapas, Mexico. Novon 8(4): 441–446. [*Z. lacandona*]

Schutzman, B., A. P. Vovides & B. Dehgan. 1988. Two new species of *Zamia* (Zamiaceae, Cycadales) from southern Mexico. Botanical Gazette 149(3): 347–360. [*Z. cremnophila, Z. soconuscensis*]

Schutzman, B., A. P. Vovides & R. S. Adams. 2000 (as "1998"). A new *Zamia* (Zamiaceae, Cycadales) from central Panama. Phytologia 85(3): 137–145. [*Z. elegantissima*]

Schweinfurth, G. 1871. Bericht über die botanischen Ergebnisse der ersten Niam-Niam Reise. Botanische Zeitung (Berlin) 29: 324–341. [*Encephalartos septentrionalis*]

Seemann, B. 1854. Flora of the Isthmus of Panama. The Botany of the Voyage of H.M.S. *Herald,* volume 6. London: Lovell Reeve. [*Zamia chigua, Z. pseudoparasitica*]

Shen, C. F., K. D. Hill, C. H. Tsou & C. J. Chen. 1994. *Cycas taitungensis,* a new name for the widely known cycad species endemic in Taiwan. Botanical Bulletin of Academia Sinica, new ser. 35: 133–140.

Sims, J. 1815. *Zamia pygmaea,* least *Zamia.* Curtis's Botanical Magazine 41: pl. 1741.

Sims, J. 1818. *Zamia furfuracea,* broad-leaved *Zamia.* Curtis's Botanical Magazine 45: pl. 1969.

Small, J. K. 1921. Seminole bread: the conti, a history of the genus *Zamia* in Florida. Journal of the New York Botanical Garden 22: 121–137. [*Z. umbrosa*]

Small, J. K. 1926. Cycads. Journal of the New York Botanical Garden 27: 127–129. [*Zamia silvicola*]

Smitinand, T. 1971. The genus *Cycas* Linn. (Cycadaceae) in Thailand. Natural History Bulletin of the Siam Society 24: 163–165. [*C. micholitzii* var. *simplicipinna*]

Standley, P. C., & L. O. Williams. 1950. *Dioon mejiae,* a new cycad from Honduras. Ceiba 1: 36–38.

Stapf, O., & J. Burtt Davy. 1926. *In* J. Burtt Davy, A Manual of the Flowering Plants and Ferns of the Transvaal with Swaziland, South Africa, part 1. London: Longmans, Green. [*Encephalartos laevifolius, E. lanatus, E. paucidentatus, E. striatus, E. transvenosus*]

Stevenson, D. W. 1982. A new species of *Ceratozamia* (Zamiaceae) from Chiapas, Mexico. Brittonia 34(2): 181–184. [*C. norstogii*]

Stevenson, D. W. 1987. Again the West Indian zamias. Fairchild Tropical Garden Bulletin 42(July): 23–27. [*Zamia amblyphyllidia*]

Stevenson, D. W. 1990. *Chigua,* a new genus in the Zamiaceae, with comments on its biogeographic significance. Memoirs of the New York Botanical Garden 57: 169–172. [*Chigua, C. bernalii, C. restrepoi*]

Stevenson, D. W. 1992. A formal classification of the extant cycads. Brittonia 44(2): 220–223.

Stevenson, D. W. 1993. The Zamiaceae in Panama with comments on phytogeography and species relationships. Brittonia 45(1): 1–16. [*Zamia cunaria, Z. dressleri, Z. ipetiensis, Z. neurophyllidia*]

Stevenson, D. W. 2002. Zamiaceae of Bolivia, Ecuador, and Peru, *in* The Biology, Structure, and Systematics of the Cycadales: Proceedings of Cycad 99, the Fifth International Conference on Cycad Biology. Memoirs of the New York Botanical Garden 87 (D. W. Stevenson, editor). [*Zamia macrochiera*]

Stevenson, D. W., & S. Sabato. 1986. Typification of names in *Zamia* L. and *Aulacophyllum* Regel (Zamiaceae); Typification of names in *Ceratozamia* Brogn., *Dion* Lindl., and *Microcycas* A. DC. (Zamiaceae). Taxon 35(1): 134–144; 35(3): 578–584.

Stevenson, D. W., & S. Sabato. 2001. Cycadales, *in* Flora de Colombia, fascicle 21. [*Zamia amazonum, Z. disodon, Z. encephalartoides, Z. hymenophyllidia, Z. melanorrachis*]

Stevenson, D. W., A. Moretti & P. De Luca. 1990. A new species of *Encephalartos* (Zamiaceae) from Tanzania. Memoirs of the New York Botanical Garden 57: 156–161. [*E. sclavoi*]

Stevenson, D. W., A. Moretti & L. Gaudio. 1995–1996. A new species of *Zamia* (Zamiaceae) from Belize and the Yucatán Peninsula of Mexico. Delpinoa, new ser. 37–38: 3–8. [*Z. polymorpha*]

Stevenson, D. W., S. Sabato & P. De Luca. 1996. What is *Zamia fischeri* Miquel? Delpinoa, new ser. 37–38: 9–17. [*Z. vazquezii*]

Tang, W. 1998. Focus on *Cycas hainanensis.* Encephalartos 54: 4–10.

Thiselton-Dyer, W. T. 1882. *Zamia montana.* Gardeners' Chronicle, new ser. 17(431): 460.

Thiselton-Dyer, W. T. 1883a. On a new species of *Cycas* from southern India. Transactions of the Linnean Society of London, ser. 2, Botany 5: 85–86, pl. 17. [*C. beddomei*]

Thiselton-Dyer, W. T. 1883b. Cycadaceae, preprint *from* W. B. Hemsley (1884), Biologia Centrali-Americana, Botany 3(16): 190–195. [*Dioon edule* var. *latipinna, D. spinulosum, Zamia acuminata, Z. cycadifolia, Z. lawsoniana, Z. picta*]

Thiselton-Dyer, W. T. 1902. Enumeration of the plants known from China proper, Formosa etc. Cycadaceae. Journal of the Linnean Society, Botany 26: 559. [*Cycas rumphii* var. *bifida*]

Thiselton-Dyer, W. T. 1905. New or noteworthy plants—*Cycas micholitzii.* Gardeners' Chronicle 38: 142–144.

Thunberg, C. P. 1775. *Cycas caffra,* nova palmae species descripta. Nova Acta Regiae Societatis Scientiarum Upsaliensis 2: 283–288.

Thunberg, C. P. 1782. Beschryving van tween nieuwe soorten van palmboomachtige gewassen, uit Japan en van de Kaap der Goede Hope; met eenige aanmerkingen omtrent de bloemen van de varens en dergelyke planten. Verhandelingen Uitgegeeven door de Hollandsche Maatschappye den Wetenschappen, te Haarlem 20: 419–434. [*Cycas revoluta*]

Thunberg, C. P. 1800. Prodromus Plantarum Capensium, Quas in Promontorio Bonae Spei Africes, Annis 1772–1775, Collegit, pars posterior. Uppsala: Edman. [*Zamia caffra*]

Urban, I. 1899. Species novae, pp. 291–384 *in* Symbolae Antillanae, seu, Fundamenta Florae Indiae Occidentalis, volume 1. Berlin: Fratres Borntraeger. [*Zamia portoricensis*]

Van Houtte, L. B. 1846. Catalogue, no. 27. [*Zamia muricata* var. *picta*]

Vázquez-Torres, M., & A. P. Vovides. 1998. A new species of *Ceratozamia* (Zamiaceae) from Veracruz, Mexico. Novon 8: 87–90. [*C. morettii*]

Vázquez-Torres, M., S. Sabato & D. W. Stevenson. 1986. A new species of *Ceratozamia* (Zamiaceae) from Veracruz, Mexico with comments on species relationships, habitats, and vegtative morpholgy in *Ceratozamia.* Brittonia 38(1): 17–26. [*C. euryphyllidia*]

Verdoorn, I. C. 1945. A new species of *Encephalartos* from the Waterberg. Journal of South African Botany 11: 1–3. [*E. eugene-maraisii*]

Verdoorn, I. C. 1949a. *Encephalartos ngoyanus.* Flowering Plants of Africa 27: pls. 1053–1054.

Verdoorn, I. C. 1949b. *Encephalartos lebomboensis.* Flowering Plants of Africa 27: pls. 1078–1079.

Verdoorn, I. C. 1951. Cycadaceae. Bothalia 6: 220–221. [*Encephalartos humilis*]

Verdoorn, I. C. 1954. Cycadaceae. Bothalia 6: 426. [*Encephalartos eximius*]

von Siebold, P. F., & J. G. Zuccarini. 1846. Florae Japonicae familiae naturales, adjectis generum et specierum exemplis selectis. Sectio altera. Abhandlungen der Mathematisch-Physikalischen Classe der Königlich Bayerischen Akademie der Wissenschaften 4(3): 123–240. [*Cycas revoluta* var. *prolifera*]

Vorster, P. 1996a. *Encephalartos aplanatus* (Zamiaceae), a new species from Swaziland. South African Journal of Botany 62(1): 57–60.

Vorster, P. 1996b. *Encephalartos brevifoliolatus* (Zamiaceae), a new species from the Northern Province. South African Journal of Botany 62(1): 61–64.

Vorster, P. 1996c. *Encephalartos msinganus* (Zamiaceae), a new species from KwaZulu-Natal. South African Journal of Botany 62(2): 67–70.

Vorster, P. 1996d. *Encephalartos senticosus* (Zamiaceae), a new species from northern KwaZulu-Natal and Swaziland. South African Journal of Botany 62(2): 76–79.

Vorster, P. 1996e. *Encephalartos venetus* (Zamiaceae), a new species from the Northern province. South African Journal of Botany 62(2): 71–75.

Vorster, P., & P. Heibloem. 1995a. *Encephalartos imbricans* (Zamiaceae), a new species from Uganda. Novon 5(4): 388–394.

Vorster, P., & P. Heibloem. 1995b. *Encephalartos successibus* (Zamiaceae), a new species from Uganda. South African Journal of Botany 61(6): 347–351.

Vorster, P., P. J. Robbertse & S. van der Westhuizen. 1988a. *Encephalartos graniticolus* (Zamiaceae), a new species from the north-eastern Transvaal. South African Journal of Botany 54(4): 363–366.

Vorster, P., P. J. Robbertse & S. van der Westhuizen. 1988b. *Encephalartos verrucosus* (Zamiaceae), a new species from north-eastern Transvaal. South African Journal of Botany 54(5): 487–490.

Vorster, P., P. J. Robbertse & S. van der Westhuizen. 1989. *Encephalartos middelburgensis* (Zamiaceae), a new species from the Transvaal. South African Journal of Botany 55(1): 122–125.

Vorster, P., P. J. Robbertse & S. van der Westhuizen. 1990. *Encephalartos aemulans* (Zamiaceae), a new species from northern Natal. South African Journal of Botany 56(2): 239–243.

Vovides, A. P., & J. Rees. 1983. *Ceratozamia microstrobila* (Zamiaceae), a new species from San Luis Potosí, Mexico. Madroño 30(1): 39–42.

Vovides, A. P., J. Rees & M. Vázquez-Torres. 1983. Zamiaceae, *in* Flora de Veracruz, fascicle 26. [*Zamia inermis, Z. purpurea*]

Vovides, A. P., M. Vázquez-Torres, B. Schutzman & C. G. Iglesias. 1993. A new species of *Ceratozamia* (Zamiaceae) from Querétaro and Hildago, Mexico. Novon 3: 502–506. [*C. sabatoi*]

Wallnöfer, B. 1996. New or noteworthy species of *Aegiphila, Styrax* and *Zamia* from Peru. Linzer Biologische Beiträge 28(2): 1056–1058. [*Z. urep*]

Walter, K. S., and H. J. Gillett, editors. 1998. 1997 IUCN Red List of Threatened Plants. Gland, Switzerland: IUCN.

Wang, D. Y., & T. Chen. 1996. Taxonomy of *Cycas* in China, chapter 4 *in* Cycads in China (F. X. Wang & H. B. Liang, editors). Guangzhou: Guangdong Science and Technology Press. [*C. elongata, C. fairylakea, C. hongheensis, C. longipetiolula, C. multifrondis, C. multiovula, C. parvula, C. tanqingii*]

Wang, D. Y., & C. Y. Deng. 1995. *Cycas segmentifida,* a new species from China. Encephalartos 43: 11–14.

Warburg, O. 1900. Cycadaceae. Monsunia 1: 178–181. [*Cycas balansae, C. miquelii*]

Ward, D. B. 1978. Rare and Endangered Biota of Florida, volume 5: Plants, pp. 122–124. Gainesville: University Presses of Florida.

Warszewicz, J. 1845. Korrespondenz rachricht. Allgemeine Gartenzeitung 32: 252–253. [*Zamia variegata*]

Weddell, H. A. 1849. Additions à la flore de l'Amérique du Sud. Annales des Sciences Naturelles, Botanique, sér. 3, 13: 249. [*Zamia brongniartii*]

Wei, F. N. 1994. A new cycad from Guangxi. Guihaia 14: 300. [*Cycas ferruginea*]

Wei, F. N. 1996. Studies on the resources and classification of the wild cycads from Guangxi (I). Guihaia 16: 1–2. [*Cycas sexseminifera*]

Wei, F. N., J. Y. Liang, & S. Q. He. 1997. Studies on the resources and classification of the wild cycads from Guangxi (II). Guihaia 17: 206–212. [*Cycas spiniformis, C. longisporophylla*]

Wendland, H. 1854. Index Palmarum, Cyclanthearum, Pandanearum, Cycadearum, Quae in Hortis Europaeis Coluntur. Hannover: Hahn. [*Ceratozamia miqueliana*]

Wieland, G. R. 1916. American Fossil Cycads, volume 2. Washington, D.C.: Carnegie Institution of Washington. [*Zamia paucijuga*]

Willdenow, C. 1806. Species Plantarum, volume 4(2). Berlin: Nauk. [*Zamia muricata*]

Wittmack, L. 1899. *Dioon edule* und *Dioon edule* var. *languinosum.* Gartenflora 48(6): 153–156.

Woodson, R. 1943. Flora of Panama. Part II. Cycadaceae. Annals of the Missouri Botanical Garden 30: 97–98.

Yang, S. L., K. D. Hill, & N. T. Hiep. 1997. *Cycas lindstromii,* a new species from southern Vietnam. Novon 7(2): 213–215.

Yang, S. L., W. Tang, K. D. Hill & P. Vatcharakorn. 1999. *Cycas pranburiensis* (Cycadaceae), a new cycad from Thailand. Brittonia 51(1): 44–47.

Zhong, Y. C., & C. J. Chen. 1997. *Cycas debaoensis*—a new cycad from China. Acta Phytotaxonomica Sinica 35(6): 571.

Zhou, L., S. Y. Yang, L. K. Fu & S. Z. Cheng. 1981. Two new species of *Cycas* from Sichuan. Acta Phytotaxonomica Sinica 19(3): 335–338. [*C. baguanheensis, C. panzhihuaensis*]

Zuccarini, J. G. 1845. Plantarum novarum vel minus cognitarum quae in horto botanico herbarioque regio Monacensi servantur, fasciculus quintus. Abhandlungen der Mathematisch-Physikalischen Classe der Königlich Bayerischen Akademie der Wissenschaften 4(2): 1–35. [*Platyzamia, P. rigida*]

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