



ETHNOBIOLOGY

Edited by

*E. N. Anderson, Deborah M. Pearsall, Eugene S. Hunn,
and Nancy J. Turner*



 WILEY-BLACKWELL

Ethnobiology

Ethnobiology

Edited by

E. N. Anderson

Department of Anthropology, University of California, Riverside, California

D. Pearsall

Department of Anthropology, University of Missouri, Columbia

E. Hunn

Department of Anthropology, University of Washington

N. Turner

School of Environmental Studies, University of Victoria



A JOHN WILEY & SONS, INC. PUBLICATION

Copyright © 2011 by Wiley-Blackwell. All rights reserved

Published by John Wiley & Sons, Inc., Hoboken, New Jersey

Published simultaneously in Canada

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4470, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at <http://www.wiley.com/go/permission>.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information on our other products and services or for technical support, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic formats. For more information about Wiley products, visit our web site at www.wiley.com.

Library of Congress Cataloging-in-Publication Data:

Ethnobiology / Edited by E. Anderson, Deborah Pearsall, Eugene Hunn, Nancy Turner.

p. cm

Includes index.

ISBN 978-0-470-54785-4 (pbk.)

I. Ethnobiology. I. Anderson, Eugene N. (Eugene Newton), 1941–, editor of compilation. II. Pearsall, Deborah M., 1950–, editor of compilation. III. Hunn, Eugene S., editor of compilation. IV. Turner, Nancy J., 1947–, editor of compilation. V. Ford, Richard I. (Richard Irving). History of ethnobiology.

GN476.7.E745 2011

578.6'3—dc22

2010042296

Printed in the United States of America

oBook ISBN: 9781118015872

ePDF ISBN: 9781118015858

ePub ISBN: 9781118015865

10 9 8 7 6 5 4 3 2 1

Contents

List of Contributors	vii	10. Reconstructing Past Life-Ways with Plants I: Subsistence and Other Daily Needs	149
Acknowledgments	ix	11. Reconstructing Past Life-Ways with Plants II: Human–Environment and Human–Human Interactions	173
1. Ethnobiology: Overview of a Growing Field	1	12. History and Current Trends of Ethnobiological Research in Europe	189
2. History of Ethnobiology	15	13. Ethnomycology: Fungi and Mushrooms in Cultural Entanglements	213
3. Ethics in Ethnobiology: History, International Law and Policy, and Contemporary Issues	27	14. Ethnoecological Approaches to Integrating Theory and Method in Ethnomedical Research	231
4. From Researcher to Partner: Ethical Challenges and Issues Facing the Ethnobiological Researcher	51	15. Assessments of Indigenous Peoples’ Traditional Food and Nutrition Systems	249
5. The World According to Is’a: Combining Empiricism and Spiritual Understanding in Indigenous Ways of Knowing	65	16. Ethnoecology and Landscapes	267
6. Ethnozoology	83	17. Traditional Resource and Environmental Management	285
7. Ethnobiology, Historical Ecology, the Archaeofaunal Record, and Interpreting Human Landscapes	97	18. Ethnobiology and Agroecology	305
8. Ethnobiology as a Bridge between Science and Ethics: An Applied Paleozoological Perspective	115	19. Linguistic Ethnobiology	319
9. Ethnobotany: The Study of People–Plant Relationships	133		

20. Cognitive Studies in Ethnobiology: What Can We Learn About the Mind as Well as Human Environmental Interaction?	335
--	------------

21. The Symbolic Uses of Plants	351
--	------------

22. Learning Ethnobiology: Creating Knowledge and Skills about the Living World	371
--	------------

Index	389
--------------	------------

List of Contributors

- Karen Adams, PhD, Crow Canyon Archaeological Center, Cortez, CO
- E. N. Anderson, PhD, Department of Anthropology, University of California, Riverside, CA
- Kelly Bannister, MSc, PhD, Director, POLIS Project on Ecological Governance, and Adjunct Professor, Faculty of Human and Social Development, University of Victoria, BC
- Andrew Barker, MS, Applied Geography, Department of Biology, University of North Texas
- Cecil Brown, PhD, Department of Anthropology, University of Northern Illinois
- Luís Manuel Mendonça de Carvalho, PhD, Botanical Museum-Instituto Politecnico de Beja
- Iain Davidson-Hunt, PhD, Natural Resources Institute, University of Manitoba
- Harvey Eshbaugh, PhD, Department of Botany, Miami University
- Nina Etkin, PhD, Department of Anthropology, University of Hawaii
- Richard I. Ford, PhD, Department of Anthropology, University of Michigan
- Catherine Fowler, PhD, Department of Anthropology, University of Nevada-Reno
- Michael Gilmore, PhD, Integrative Studies, New Century College, George Mason University
- Preston Hardison, BA, Tulalip Tribes of Washington, Tulalip, WA
- Christine Hastorf, PhD, Department of Anthropology, University of California, Berkeley
- Eugene Hunn, PhD, Department of Anthropology, University of Washington
- Leslie Main Johnson, PhD, Dept of Anthropology, Athabaska University
- Harriet Kuhnlein, PhD, School of Dietetics and Human Nutrition, McGill University, and Founding Director, Center for Indigenous Peoples' Nutrition and Environment
- Dana Lepofsky, PhD, Department of Anthropology, Simon Fraser University
- Łukasz Łuczaj, Wild Garden, Pietrusza Wola, Wojaszówka, Poland
- Letitia McCune, PhD, unaffiliated
- Heather McMillen, PhD, People and Plants International, Bristol, VT
- Justin Nolan, PhD, Department of Anthropology, University of Arkansas
- Manuel Pardo-de-Santayana, Senior Lecturer, Universidad Autónoma de Madrid, Spain
- Deborah Pearsall, PhD, Department of Anthropology, University of Missouri, Columbia
- Andrea Pieroni, University of Gastronomic Sciences, Pollenzo/Bra, Italy
- Ray Pierotti, PhD, Ecology and Evolutionary Biology and Global Indigenous Studies, University of Kansas
- Charles Randklev, PhD Candidate, Biological Sciences, University of North Texas
- Caissa Revilla-Minaya
- Norbert Ross, PhD, Department of Anthropology, Vanderbilt University

viii List of Contributors

Susan Smith, PhD, Bilby Research Center, Northern Arizona University, Flagstaff, Arizona

Peter Stahl, PhD, Department of Anthropology, State University of New York, Binghamton

Ingvar Svanberg, PhD, Uppsala Centre for Russian and Eurasian Studies, Uppsala University, Sweden

Tamara Ticktin, PhD, Department of Botany, University of Hawai'i-Manoa

Nancy Turner, PhD, School of Environmental Studies, University of Victoria

Steve Wolverton, PhD (Anthropology), PhD (Environmental Science), Department of Anthropology, University of North Texas

Sveta Yamin-Pasternak, PhD, Department of Anthropology, University of Alaska-Fairbanks

Rebecca Zarger, PhD, Department of Anthropology, University of Florida

Acknowledgments

We wish to acknowledge the individuals, many of them members of Indigenous and local communities, who gave so much of their time and energy to the research embodied in this volume, and especially to those whose knowledge is detailed in this volume. To these individuals and groups this volume is dedicated. We also thank the universities and other institutions and granting agencies that supported this research. We are very grateful to Ms. Anna Ehler and the staff at Wiley-Blackwell Publishers for all their dedicated work on the production of this volume.

Chapter 1

Ethnobiology: Overview of a Growing Field

E. N. ANDERSON

Department of Anthropology, University of California, Riverside, CA

DEFINITION OF A FIELD	1
AN INTERDISCIPLINARY FIELD	2
LOCAL BIOLOGY AS SCIENCE	3
ETHNOBIOLOGY SPREADS OUT	6
ETHNOBIOLOGY GOES INTERNATIONAL	8
“TEK” AND ITS SORROWS	8
MOVING TOWARD MORE LOCAL PARTICIPATION	9
INTERFACING WITH POLITICAL ECOLOGY	10
ETHNOBIOLOGY AS FUTURE	11
A NOTE ON USAGE	11
ACKNOWLEDGMENTS	12
REFERENCES	12

God put the fever in Europe and the quinine in America in order to teach us the solidarity that should prevail among all the peoples of the earth.

—Bolivian folk botanist (quoted Whitaker 1954, p. 58)

DEFINITION OF A FIELD

Ethnobiology is the study of the biological knowledge of particular ethnic groups—cultural knowledge about plants and animals and their interrelationships. This textbook documents in summary form the progress and current status of ethnobiology. Ethnobiology remains a small, compact, and rather specialized field, developing from earlier work in ethnobotany

Ethnobiology. Edited by E. N. Anderson, D. Pearsall, E. Hunn, and N. Turner
© 2011 Wiley-Blackwell. Published 2011 by John Wiley & Sons, Inc.

and ethnozoology (Ford 2001, 2011; Hunn 2007). However, it covers a broad range of approaches, from strictly cultural and linguistic studies to strictly biological ones. Toward the former end are studies that focus on semantics: vocabulary, linguistic concepts, meaning and symbol, and art and religion. In the middle zone, where anthropology and biology fuse, are studies of how people actually think about their use and management of plants: ethnomedicine, food production and consumption, and ethnobotany. Further toward biology, but still using anthropological approaches, are the archaeological fields of archaeozoology and archaeobotany, in which we reconstruct past lifeways from biotic data. Studies of natural products chemistry, field agronomy, genetics, and crop evolution verge on purely botanical approaches, and as such are not included in the present book.

In this volume the field is divided into archaeological and ethnographic researches, and within that by major biological units: plants, animals, fungi, and aquatic life-forms. Special topics include food and foodways (a research area with a vast and often specialized literature), landscape, and traditional resource management. Since many chapters deal primarily with hunting-gathering peoples, a chapter on particular problems of agricultural studies has been added. Very important, indeed basic to our entire project, are chapters on the history of the field and on ethics.

AN INTERDISCIPLINARY FIELD

These various studies blend imperceptibly into their related (or parent) fields. Economic botany, once largely confined to prospecting for new crops and medicines, has moved close to ethnobotany. The “archaeo” fields have close ties with archaeology. Linguistic anthropologists link studies of native categories to linguistic and semantic theories. Major contributions to our knowledge of how people think about nonhuman lives have been made by anthropologists like Claude Lévi-Strauss (e.g., 1962), psychologists like Douglas Medin (Ross, 2011), and social thinkers like Bruno Latour (2004, 2005). Conversely, ethno-science has contributed important understandings to linguistics and communication studies (Sanga and Ortalli 2003). Cognitivists draw on this work for studies of human cognition (e.g., Kronenfeld 1996).

Many students of traditional knowledge do not now call themselves ethnobiologists, although they usually use ethnobiological techniques. They have often gotten them from H. Russell Bernard’s text *Research Methods in Anthropology* (2006) or similar general works; ethnobiological methods have gone mainstream.

Ethnobiological knowledge is far too important to ignore. It is vitally important in the traditional cultures of the Indigenous and rural societies of the world, and these societies do not want to lose it. In many areas Indigenous people have now taken a leading role in recording, saving, and using this knowledge. Traditional knowledge is emerging as important, even necessary, for managing key resources and ecosystems. Ethnobiology continues to be a source for knowledge about medicines, crops, agricultural techniques, conservation and management, and much more.

Much of this knowledge is *traditional*, that is, learned long ago and passed on with varying degrees of faithfulness for at least two or three generations. However, ethnobiological knowledge can change rapidly. Every tradition had a beginning (cf. Hobsbawm and Ranger 1983), and was itself a new creation in its time. Ecosystems change, new plants and animals arrive, and people learn new ways of thinking; ethnobiological systems change accordingly, and are typically flexible and dynamic. Field-workers have observed new knowledge being incorporated into systems around the world.

Ethnobiology has usually been concerned with small-scale, local, and Indigenous peoples. “Indigenous” originally meant “native to the place where they live”, as opposed to recent immigrants. Now, however, it has acquired a political meaning, never officially defined but generally accepted. (See, e.g., the United Nations in their Declaration on the Rights of Indigenous Peoples, final version adopted in 2007, in which the definition is implicit but not explicit: http://www.cbc.ca/news/pdf/UN_declaration.pdf.) This restricts the term to colonized minorities, such as the Native peoples of the New World and Australia. It has become problematic in countries such as China, dominated by majorities that are Indigenous by the old standard and in which the minorities are not officially considered to be “colonized”. Such minorities are always referred to as “Indigenous” in the literature, however, and are treated as such by the United Nations. Much more problematic are Creole groups like those of Louisiana and the Caribbean. They have a rich ethnobiological tradition (Brussell 1997; Quinlan 2004). They developed where they now live, had no prior history, and often have a continuity reaching back hundreds of years. They are often minorities and are sometimes subjected to discrimination. They tend to arise from immigrant communities, and they remain hard to classify. Ethnobiologists have never restricted their studies to “Indigenous” groups (by any definition), but the question of indigeneity becomes serious in dealing with intellectual property rights and other ethical issues.

Some have contested the use of terms like “ethno-”, “folk”, and “traditional” for local knowledge, holding that such terms are pejorative. I find this attitude deplorable; the correct procedure should be to insist on the value of folk creations and traditional ideas and practices. Folk, ethnic, and traditional music, art, dance, drama, narrative, and food have certainly won full appreciation and acceptance from every sensitive observer. Folk knowledge deserves the same respect. Claiming that “folk”, “ethno-”, and “traditional” are *pejorative* terms is unacceptable snobbery.

LOCAL BIOLOGY AS SCIENCE

The extent to which local traditions are considered “science” depends on the definition of science used. The Latin word *scientia* covered cognitive knowledge in general, but certainly focused on knowledge of the wide outside world. The Latin *historia naturalis* more specifically covered the nonhuman environment, but could include humans in their relationship with nature. Both terms were brought into English fairly early. Other languages had similar words, not equivalent to modern “science” but comparable to *scientia*. The Chinese, for instance, had a rich and complex language for talking about knowledge of the “myriad things”, and had a thoroughly logical and scientifically analytic tradition (Harbsmeier 1998) including such things as case–control experiments as early as the second century BC (Anderson 1988). India and the Middle East had ancient and well established scientific traditions, in constant touch with and greatly inspired by the Greeks (see, e.g., Nasr 1976). Recently, arguments for viewing traditional Mesoamerican knowledge as science have been adduced very persuasively by Roberto Gonzalez (2001; Anderson 2000).

The broad consonance between folk and scientific systems around the world is devastating to the view that science is purely a cultural or social construction. People everywhere focus on inferred biological relationships, and see more or less the same (obvious) ones. Brent Berlin (1992) and Scott Atran (1990) pointed to striking similarities in cross-cultural naming as proof that humans have a natural tendency to see and classify the world in a particular way—among other things, inferring natural kinds (see also Hunn and Brown, 2011). Roy Ellen has criticized this view in a number of publications (notably Ellen 1993), but his

critique stands more in the line of qualification than of refutation. “Bird” remains a universal concept even though cultures may differ on whether bats are birds or not. (The vast majority lumps them as birds; the Germanic world is quite unusual in having long grouped them with furry creatures, as zoologists do—German *fledermaus*, middle English *reremouse*, both meaning “flying mouse”.) The fact that some cultures class mushrooms with plants, some (correctly!) with animals (Lampman 2008), and some as totally separate (Yamin-Pasternak, 2011) is, again, less interesting than the fact that almost everybody recognizes them as a category.

On the other hand, the real differences between cultures (Ellen 1993) and the strong influence of utilitarian reality on systems (Hunn 1982, 2011) shows that science, whether folk or contemporary, is indeed a cultural construction. The point is that it is constructed on the basis of continual interaction with an external biological reality, which must be accurately apprehended to allow survival in society.

Modern laboratory science has diverged somewhat from traditional classifications (as they have from one another). Thus Carol Kaesuk Yoon (2009) sees a “clash” because genetics has now showed us that birds and dinosaurs are closer than lizards and dinosaurs, and for that matter humans and carp are closer than carp and sharks. Indeed, this somewhat problematizes the classic life-form categories “bird” and “fish”. However, traditional taxonomies may be more accurate than European science. The Yucatec Maya, for instance, lump branchtip-nesting orioles (three species known to them) as *yuyum* and palm-crown-nesting ones (another three species) as *jonxa’anil* (literally, “palm dwellers”). Genetic research has just confirmed that these are two separate clades within the genus *Icterus*. The Sahaptin of Washington State correctly distinguished two plants that botanists had failed to separate (Hunn and Brown, 2011).

“Science”, in the broad sense that includes these traditions, means knowledge of the natural world that is not only more or less accurate but that is predictive, defined by certain key postulates, and able to incorporate new knowledge. Gonzalez points out that the postulates need not always be true; the Zapotec he studied believe in the Earth God and deduce much from this. More to the point, the Zapotec share with all the Old World traditions a belief in “hot” and “cold” qualities that go beyond temperature to include many phenomena. This belief lasted in European scientific thought until about the end of the nineteenth century, and attenuated forms of it continue (Anderson 1996). Indeed, much earlier Western science is now discredited, from astrology to static continents. Some current international science, such as string theory, is controversial enough that many serious experts would class it with the Earth God. Science need not be true. In fact, a science made up of proven facts is a dead science; science must explore and challenge. Modern laboratory science is not some sort of perfect, flawless enterprise of modeling and analysis, but as human as any other activity (Latour 2004, 2005; Merton 1973; Wimsatt 2007).

Various modern definitions of science are more restrictive. Positivist traditions insist on explicit deduction and verification or falsification procedures (Kitcher 1993; Martin and McIntyre 1994; Popper 1959). Some add requirements for predictive mathematical modeling or highly controlled experimentation (laboratory or very systematic field trials). The latter would, of course, rule out not only folk science but all field sciences, from geomorphology and astronomy to most of field biology and paleontology. It would also rule out all Western science before the late nineteenth century. This seems excessive; cutting off modern science from the Greek, Near Eastern, and Renaissance, and even from the “Scientific Revolution” of the seventeenth century, does not seem useful. If we are to recognize ancient Greek science as such, we cannot deny the label to comparably elaborate and rationalized non-Western traditions.

Traditional knowledge, however, is not always separated from other activities or given a name equivalent to “science”. Gonzalez (2001) had to separate, artificially, Zapotec “science” from what the Zapotecs simply called “knowledge”. Traditional knowledge is holistic, or at least it usually fuses what English would call “science” with what English would label “religion”, “economics”, and so forth.

Thus, ethnobiologists, from the beginning, have dealt with traditional ecological knowledge as one package—ideally recording myths, religious practices, spiritual beliefs, economic activities, kinship associations, and other related material along with strictly cognitive or “scientific” knowledge of plants and animals. An early and excellent work of this sort was Frank Cushing’s study of maize and other grains among the Zuñi of New Mexico; it originally appeared as articles in *The Millstone*, a trade journal, in 1884 and 1885 (Cushing 1920). Work of another pioneer, Paul Radin, has recently been edited and discussed by Callicott and Nelson (2004). Radin was among the first to examine both the nature of traditional knowledge and the traditional knowledge of nature.

Ethnobiologists often study the religious symbolism of plants and animals (Hunn 1979). Flowers, leaves, medicinal herbs, and other botanicals are routinely drawn on for religious symbolism (Carvalho, 2011). Every culture that knows trees seems to have a sacred tree or a set of tree myths. The birch in north Eurasia, the oak in ancient European paganism, the banyan in south and southeast Asia, and the red cedar (*Thuja plicata*) in northwest North America, provide examples. The “tree of knowledge of good and evil” in the Bible is traditionally considered an apple, but apples did not grow in the regions known to the ancient Israelites, and the tree might have been the date, the wheat plant, or a purely imaginary tree.

Animals are similarly revered. The cow in India has attracted attention (Harris 1966; Simoons 1994). Also in India, the wild goose (*hamsa* in Sanskrit; the word is cognate with “goose”, “gander”, and *Anser*) is the symbol of the soul, because wild geese appear in the fall and disappear in the spring, never staying to breed. In ancient times nobody had the slightest idea where they went or how they reproduced. In Mesoamerica, the duck is the symbol of the wind god (Ehecatl in Aztec civilization), perhaps for similar reasons; millions of ducks used to winter in Mesoamerica, most of them disappearing in spring. The ornithologist Herbert Friedmann devoted many years to exploring the religious symbolism of animals and birds in Renaissance paintings of Saint Jerome (Friedmann 1980).

Traditional people generally distinguish between such lore and their working knowledge of nature. They recognize the difference between natural taxonomies and special-purpose, human-adapted ones. They know perfectly well the difference between a well known, well practiced technical operation and a prayer. The former is effective because one knows what to do; the latter is only effective because the gods might possibly listen. (The marginal and long debated case of “magic” might problematize this, but may be ignored here.)

Modern ethnobiology was born from this research on the traditional classification and cognition of nature. It developed from biological, linguistic, and cognitive anthropological research at Harvard and Yale in the 1950s and early 1960s. This led to the field of “ethnoscience”, a term coined by a group of George Murdock’s students at Yale in the 1950s. Notable among these was Harold Conklin (1957), whose ethnobotanical work was mentored by the veteran botanist H. H. Bartlett. Charles Frake (1980) and others at Yale were quickly recruited. Scholars at Harvard and other leading schools very soon followed suit. Separate threads later joined in this cognitive program, including Cecil Brown’s work (1984; Hunn and Brown, 2011), which showed the universality of life-form categories like “tree”, “vine”, “snake”, and “bird”, and then Brent Berlin’s great summary *Ethnobiological Classification* (Berlin 1992). Medical ethnobiology also flourished (e.g., Etkin 1986, 1994, 2006; Etkin et al., 2011; Lewis and Elvin-Lewis 2003; Moerman 1998).

The new cognitive and cultural approaches of ethnobiology had been substantially pre-saged by developments in ethnobotany. In this the University of Michigan was critically important, because of the links there between ethnobotany and archaeoethnobotany (Ford, 2011) as well as cognition, notably Scott Atran's work (Atran 1990; Ross, 2011). Other important centers of archaeoethnobiology, including the University of Arizona and the University of Florida (where Elizabeth Wing led archaeozoology over a long and distinguished career), had increasing influence within ethnobiology from the 1960s onward. Specialized archaeological techniques for analyzing flora and fauna arose (Adams 2001; Delcourt and Delcourt 2004; Pearsall 2001; Piperno and Pearsall 1998; Weber 2001; Weber and Belcher 2003; and the many relevant chapters in the present book).

In the 1960s, Harvard botanist Richard Evans Schultes shifted his self-label from economic botanist to ethnobotanist. As a leading scholar and popularizer of traditional medicines and drugs, he had much influence (e.g., Schultes 1976, 1978; Schultes and Hofmann 1992). He and his associate Siri von Reis Altschul edited a major (if uneven) review of the field of ethnobotany (1995). Thereafter, economic botany attracted more and more ethnobotanists. Scholars in both fields became more interested in careful documentation of traditional societies than in appropriating new plants for international economic purposes. The Society for Economic Botany (founded in 1959, currently around 800 members) has become strongly ethnobotanical, along with its journal *Economic Botany* (founded 1947 by Edmund Fulling). Economic botany, however, does not include ethnozoology or—usually—archaeological approaches.

The rise of ecological and environmental anthropology has led to a large border zone developing between mainstream ecological anthropology and the ethnobiological approach. At first, relations could be far from cordial, as is seen in one leading cultural ecologist's scathing denunciation of ethnoscience (Harris 1968) and subtler but unmistakably dismissive answers (Frake 1980). Time led to accommodation and mutual learning, and ethnobiology was incorporated into ecological anthropology.

Inevitably, younger scholars in archaeobotany, archaeozoology, cultural ecology, and ethnoscience discovered each other. The Society of Ethnobiology was founded in 1977 by paleoethnobotanists Stephen Emslie and Steven Weber. Its existence became widely known after the first meeting, and ethnobiologists joined in numbers. The new core group was exciting. For years, the Society of Ethnobiology was a major powerhouse of archaeological and cultural-anthropological theory and method.

The society has continued expand its intellectual base and to flourish. It now has over 500 members, and publishes the *Journal of Ethnobiology* (since 1981).

ETHNOBIOLOGY SPREADS OUT

More and more anthropologists have found ethnoscience methodology useful in studies far beyond natural history. Steven Feld used elicitation techniques not only to study the biology of the Kaluli of Papua New Guinea, but also their classification of musical genres and their discourse on emotions (Feld 1982). Later Feld collaborated with Keith Basso in editing *Senses of Place* (1996), which launched a tradition of studying cultural perceptions of landscapes (see Johnson and Davidson, 2011). Ethnoscience methods have been propagated in studies of the arts, emotions, learning, and phenomenology, and have been absorbed into the broad stream of anthropological methods. Since early anthropology, many of those interested in ethnology, ethnobiology, and cognition have studied traditional map sense, navigation, ethnogeography, and place naming. This chain runs from Franz Boas and his students

in the late nineteenth and early twentieth centuries up to recent work. Recent studies show that human and animal abilities to navigate, map, and track are far greater than previously thought. Contrary to old ideas about human cognitive limitations in this regard, humans form extremely detailed mental maps (not like printed maps, but no less effective) as well as navigating by landmarks and known paths, and have complex and multiply structured mental representations of landscapes (Istomin and Dwyer 2009). This allows us to understand the incredible performances of traditional navigators (Gladwin 1970; Hutchins 1995).

A major new area of research has been ethnoecology. This field was developed largely in Mexico, by the great scholar and conservationist Victor Toledo (1992, 2002). A journal, *Etnoecología*, began under his direction, but did not survive. More recently, ethnoecological research has addressed landscape management and modification by hunting and gathering peoples (Nazarea 1999). Formerly considered to be almost without impact on “natural” landscapes, these groups have proved to be extremely important creators of vegetation types and biotic assemblages. The research in question brings together biologists (M. K. Anderson 2005; Turner 2005; Davidson and Johnson, 2011), archaeologists (Delcourt and Delcourt 2004), geographers (Denevan 2001; Doolittle 2000), cultural anthropologists (Blackburn and Anderson 1993), and others (even political scientists; Kay and Simmons 2002) in impressive cooperation.

These understandings have seriously problematized “saving wild nature”. If wild nature is not only not wild but not natural either, how can we save it? Do we maintain traditional bow-hunting? The volume edited by Kay and Simmons poses this question. Europe has had to face similar dilemmas for a long time, in dealing with the question of saving their agroecological landscapes. National parks there are usually set up to preserve landscapes known to be human-created; indeed, there are no even remotely “natural” landscapes in Europe (Blavascunas 2008).

As ethnobiologists realized that they had to look comprehensively at entire traditional knowledge systems, they began producing large works with wide appeal, and publishers were often charmed. We now have beautiful large-format works like Richard Felger and Mary Beth Felger’s *People of the Desert and Sea* (1985) and David Yetman’s *The Great Cacti* (2007), as well as Amadeo Rea’s great trilogy of Oodham knowledge, *At the Desert’s Green Edge* (1997), *Folk Mammalogy of the Northern Pimans* (1998), and *Wings in the Desert* (2007). Rea mentored Gary Paul Nabhan, one of the earliest members of the Society of Ethnobiology. Nabhan’s numerous books (see, e.g., Nabhan 1987, 1997, 2008) have won many prizes for nature writing and popular science.

Botanic gardens, among others, have published many ethnobotanies, such as the huge *Ethnoflora of the Soqotra Archipelago* (Miller and Morris 2004) from the Royal Botanic Garden Edinburgh. Major journals have devoted special issues to ethnobiology (e.g., Ellen 2006).

Following the success of Richard Evans Schultes’ books on drug plants, and the revival of interest in traditional remedies and alternative medicine in general, many popular and well illustrated medical floras have appeared. “Trade” publishers have thus seen it worthwhile to publish some landmark ethnobiological works, such as Daniel Moerman’s *Native American Ethnobotany* from Timber Press (1998).

Ironically, just as it was becoming more popular in the wider world, ethnobiology was facing some academic opponents. Biology has moved toward molecular and cellular research, where funding has been better than for organismal biology. Agricultural research, which long provided support for economic botany and zoology, has faced limited funding. Anthropology in the 1980s turned dramatically away from scientific and interdisciplinary approaches. Cultural and social anthropology became overwhelmingly dominated by

“postmodern” approaches derived from philosophical and literary studies. Not only scientific anthropology but even mainstream cultural anthropology was largely displaced as a source of ideas by literary criticism and interpretive history. In ecological anthropology, the focus shifted from studies of traditional cultures to studies of the effects of modernization, globalization, and world politics on local groups. Usually, this reduced these groups to the status of mere victims, their own traditions and languages being unimportant. Ecological and environmental anthropology lost ground at several universities. Fortunately there were always exceptions to this trend, and after 2000 anthropology moved back toward its traditional focus.

ETHNOBIOLOGY GOES INTERNATIONAL

In 1988, the International Society of Ethnobiology emerged (see Stepp et al. 2002). European, Latin American, Asian, African, and Oceanian ethnobotanists now abound. The field is one that can and does flourish in “Third World” countries, since it requires little fixed capital investment and since most Third World countries have diverse populations with many rich traditions of local knowledge and use of flora and fauna.

Ethnobiology has flourished in Mexico. The University of Yucatan has been issuing an “Etnoflora Yucatanense” series for almost 20 years, and it includes several superb and major works in ethnobotany, culminating in a monumental compilation by Arellano et al. (2003), which lists almost 1000 species of plants with their uses and names in Spanish and/or Yucatec Maya. A leading ethnoecologist, Enrique Leff, has also had influence far beyond specialized circles; Leff is in fact one of the great social theorists of Latin America. His work is, alas, far too poorly known in English (see Leff 1995). Latin American ethnoecology has linked outward to the whole area of Indigenous rights and politics, and thus has gone beyond the scope of the present volume. A survey of this area for Anglophone readers was sorely needed, and has indeed appeared, in Arturo Escobar’s magistral survey and study *Territories of Difference* (2008).

An Indian ethnobotanical society emerged in India around S. K. Jain in the 1970s; Jain’s journal *Ethnobotany* continues to flourish. The importance of work in India, China, and other countries has made ethnobiology one of the few scientific fields in which Third World countries are leading players with important journals and centers. Ethnobiology has been something of a western hemisphere field, but rapidly increasing numbers of studies in the eastern hemisphere are making it more international.

The clearest and worst limitation of the present volume is its lack of specific and detailed coverage of these regional traditions. Unfortunately, no one has stepped forward to provide a ready synthesis. (In any case, the present volume was intended to introduce topical areas, not geographic ones. A major effort by a number of European ethnobiologists led to a chapter reviewing European ethnobiology, but no comparable efforts could be organized in other areas.) Obviously, a world summary of ethnobiology is sorely needed, and we hope to address this in the near future.

“TEK” and its Sorrows

An emergent problem is a cost of partial success at convincing governments and agencies that traditional knowledge is worthy of attention. Traditional ecological knowledge has become “TEK” (often pronounced as one syllable, “tek”). From a vast and fluid pool of wisdom, it has become a bureaucratic object. Paul Nadasdy (2004, 2007) has pointed out

that, once thus pigeonholed, TEK can all too often be quarantined and ignored, and so can the people who possess it (see also Schreiber and Newell 2006). Even among those with better intentions, TEK is often relegated to a past that is considered possibly romantic but surely irrelevant. This is a false stereotype. TEK is highly accurate, flexible and adaptable, and thus extremely relevant to all aspects of managing natural resources in today's world. In fact, the survival of the human race may depend on saving not only the specifics (plant drugs, new crops) but, more importantly, the traditional ways of managing resources and motivating people to conserve them (Anderson 1996).

One of the problems Nadasdy identifies is that traditional people often have trouble discussing their knowledge in analytic language. This is because so much of TEK is experiential and procedural, or culturally constructed from procedural knowledge. It is notoriously difficult to talk about procedural knowledge, as all psychologists know (and see Goulet 1998; Marcus 2002). Conversely, the bureaucratic biologists Nadasdy studied were not field trained (as biologists in my generation were); they were apparently trained almost exclusively in classrooms and laboratories. They had only analytic, linear knowledge of biology. They lacked the hands-on, experiential, procedural knowledge that biologists of earlier generations acquired. Field time with First Nations persons improves the situation (Nadasdy, pers. commun., 2007). Conservation biologists and other practical field workers need to work with rural traditional people, for mutual benefit.

Such considerations have led to a renewed interest in how traditional knowledge is transmitted. We know that children learn what their parents and peers find important. Children attend to their elders' ideas of salience. We also find that traditional knowledge everywhere is taught through stories, songs, physical participation in activities, and other methods that engage the emotional, aesthetic, and physical as well as the cognitive portions of experience. This is total-person learning. It is part of a rich, full engagement with the world, rather than being isolated as rote memorization in a classroom. The desperate need of the modern world to educate children about nature and to use these ways of doing it is now well known (Louv 2005). Once again we can learn from traditional cultures. A major need of ethnobiology is to point out the different "ways of knowing" (Goulet 1998) and to teach people to learn each others' ways.

MOVING TOWARD MORE LOCAL PARTICIPATION

The 1990s saw a rapid growth of new ethical standards (see Bannister and Hardison, and Gilmore and Eshbaugh, present volume). Certain notorious and well publicized cases of appropriating traditional wisdom for individual gain led to coining the term "biopiracy", and to powerful opposition to it. As early as the 1960s, Mexico failed to capitalize on its original monopoly on the wild yams that were the source of the birth control pill; the story is told in a major recent history book (Soto Laveaga 2009). The most noted cases involved attempts to monopolize traditional South Asian ethnobotanical knowledge through patenting. United States patent rules in the 1980s and 1990s had evolved to favor corporations and patenters against public access, "prior art", and claims of common knowledge. This allowed a scientist to attempt to patent neem oil from the tree *Azadirachta indica*, used medicinally in India (and more or less everywhere Indians have gone) for thousands of years (Shiva 1997). Then an American attempted to patent the term "basmati", originally a North Indian word for fragrant rice varieties, for a new rice variety that was not even fragrant. This would have made it difficult or impossible to use the term for real basmatis in the lucrative export market. Indian scientists, and eventually the Indian government, took the lead in fighting such

expropriation. Vandana Shiva (1997, 2001) has been a powerful and vocal advocate for tighter ethical standards. She and many others have argued that current pro-corporation interpretations of patent law, especially by the U.S. Patent Office, are extreme, counterproductive, and on very shaky legal ground (see Aoki 2008; Brown 2003; Vogel 1994, 2000).

This led to questioning even legitimate and well intentioned plant and medicine exploration and bioprospecting (Berlin and Berlin 1996, 2000; Hayden 2003), and eventually led to the virtual shutdown of such efforts. The drug firms, in particular, which spend large sums and take large risks in developing drugs from plant and animal sources, have essentially closed down their natural products operations except in cases where open access and public record are undeniable. Paradoxically, the success of the giant firms in getting their way in patenting had shut down an entire promising industry. Many ethnobiologists know excellent remedies that would help the world, but their lips are now sealed. The toll in human suffering increases every day that this impasse remains unresolved.

Full collaboration with local and Indigenous people is no new thing in anthropology; Native American ethnographers have been active since the mid-nineteenth century. An early classic of ethnobotany was Gilbert Wilson's collection of agricultural knowledge from Buffalo Bird Woman, a Hidatsa farmer (Wilson 1917). It has recently reissued under Buffalo Bird Woman's name. Many works followed, as collections of "native life histories" and other relevant documents became standard in anthropology. Native Americans and other Indigenous people often became professional anthropologists and ethnographers and did their own collecting; one ethnobiologically important example is the Greenlander ethnologist Knud Rasmussen (see, e.g., 1999). Among more recent classics are the works of Ian Saem Majnep, a Papua New Guinea subsistence farmer and folk biologist who has collaborated with Ralph Bulmer (Majnep and Bulmer 1977, 2007). Jesus Salinas Pedraza's wonderful ethnography of his Nyahnyu community in Mexico (Bernard and Salinas Pedraza 1989) also contains much fascinating ethnobiological material; an outsider would not be likely to record under uses of the mesquite tree the fact that it is delightful to lie under the tree and watch the birds playing in it.

It has now become common for Indigenous and non-Indigenous coworkers to coauthor books, as in the case of the many ethnobotanies of Nancy Turner and collaborators (e.g., Turner et al. 1990; and for other examples see, e.g., Anderson and Medina Tzuc 2005; Hunn 1990). Larry Evers worked with Yaqui deer-singer Felipe Molina on a collection, *Yaqui Deer Songs* (Evers and Molina 1987), that brings together some of the finest nature poetry anywhere. We are, hopefully, at the beginning of a major flowering of Indigenous works on local biological knowledge.

INTERFACING WITH POLITICAL ECOLOGY

Political ecology arose as an early spinoff of cultural ecology; the term was introduced by Eric Wolf (1972). It rose to prominence in the 1990s. Political agendas led to renewed interest in traditional knowledge. Conversely, those interested in traditional knowledge became more and more concerned with its fate in the modern world. Many major works in political ecology are particularly relevant to ethnobiology, and typically draw on its methodology (see, e.g., Agrawal 2005; Cruikshank 2005; Tsing 2005; West 2006). The boundary between political ecology and ethnobiology is completely blurred by research that focuses on the political ecology of particular species and of conservation efforts, such as Janice Harper's *Endangered Species* (2002) and Celia Lowe's *Wild Profusion* (2006). Problems of nature

reserves, which often exclude the very Indigenous people who created the “nature” in the first place, have received particular attention (West et al. 2006; cf. Scott 1998).

Ethnobiologists have been able to address ethical and political–ecological questions on the basis of highly rigorous knowledge of actual circumstances among Indigenous and small-scale communities. Major collections of papers addressing these issues have now appeared (Laird 2002; Maffi 2001; Stepp et al. 2002). Anderson (2003, 2005; Anderson and Medina Tzuc 2005) used ethnobiology to address political ecology. Eugene Hunn (1990) addressed political questions in a major ethnobiological study. Nancy Turner’s ethnobotanical work has moved toward political application (Turner 2005).

ETHNOBIOLOGY AS FUTURE

Johann Herder (2002; original papers, late eighteenth century) was apparently the first person, at least in the Western world, to argue explicitly and in detail that other cultures deserve full consideration and appreciation as creations of the human spirit. This view entered anthropology, largely via Adolph Bastian and his student Franz Boas. Boas spent his life trying desperately to record local traditions, especially art and oral literature, before they went down before the onslaughts of racist colonialism. The Herder–Boasian view became rather widespread, though far from universal, in anthropology. It remains almost unknown in many other fields. Tragically (from an ethnobiological point of view), it is particularly lacking in the fields of economic development and global education. In spite of lip service, most development and change agents display little recognition that local traditions—including TEK—are worthy of respect.

Indeed, recent decades have seen a sad retreat even in anthropology from the old goals of valuing diversity, saving local achievements, and respecting other people’s works. Much of the Boasian agenda is dismissed as “salvage ethnography”. Some fear that Boasian ethnography freeze-frames a culture. Yet, field ethnobiologists are aware that folk knowledge systems are dynamic and innovative, and we study their changes and developments assiduously.

There is also a desperate need to record knowledge that is being forgotten, and, far more importantly, to save the cultures, languages, and ecosystems whose death is causing the forgetting. Many of the finest creations of the human spirit are dying out. Often, the destruction is genocidal; few nations are not stained with the blood of their Indigenous peoples.

More often today the destruction of culture is the result of deliberate or inadvertent policies in education, media, and popular commercial arts. If people wish to give up their traditions, outsiders cannot stop them, but too often Indigenous groups have been bullied or tricked into accepting their oppressors’ destructive agendas. All persons of goodwill must join to fight genocide and culturicide. In recent decades many groups have recovered at least some of their languages and cultural forms from old ethnographies. Denying future generations the right to do this, and to protect the habitats on which they depend to maintain their ways of life, is a social injustice. Ethnobiology is a major part of the ongoing effort to save these natural and human worlds.

A Note on Usage

Per Canadian practice (many of our authors being Canadian), and increasingly the practice elsewhere, Indigenous is capitalized. (In Canada it refers to a specific designated set of people, and thus is a proper noun; elsewhere, usage is moving in that direction.)

Otherwise, authors use standard, linguistically-accurate transliterations and spellings, but have been free to choose when there are alternative adequate systems.

ACKNOWLEDGMENTS

E. N. Anderson is deeply grateful to all the authors for their exemplary cooperation and help through the long gestation of this project.

REFERENCES

- ADAMS K. Looking back through time: southwestern U.S. archaeobotany at the new millennium. In: FORD RI, editor. *Ethnobiology at the millennium: past promise and future prospects*. Anthropological Papers 91, Museum of Anthropology. Ann Arbor: University of Michigan; 2001. p 49–100.
- AGRAWAL A. *Environmentality: technologies of government and the making of subjects*. Durham (NC): Duke University Press; 2005.
- ANDERSON EN. *The food of China*. New Haven (CT): Yale University Press; 1988.
- ANDERSON EN. *Ecologies of the heart*. New York: Oxford University Press; 1996.
- ANDERSON EN. Maya knowledge and “science wars”. *J Ethnobiol* 2000;20:129–158.
- ANDERSON EN. *Those who bring the flowers*. Chetumal, Quintana Roo: ECOSUR; 2003.
- ANDERSON EN. *Political ecology in a Yucatec Maya community*. Tucson: University of Arizona Press; 2005.
- ANDERSON EN. *The morality of ethnobiology*. Available at <http://www.krazykioti.com>.
- ANDERSON EN, MEDINA TZUC F. *Animals and the Maya in southeast Mexico*. Tucson: University of Arizona Press; 2005.
- ANDERSON MK. *Tending the wild: Native American knowledge and the management of California’s natural resources*. Berkeley: University of California Press; 2005.
- AOKI K. *Seed wars: controversies and cases on plant genetic resources and intellectual property*. Durham: Carolina Academic Press; 2008.
- ARELLANO RODRÍGUEZ JA, SALVADOR FLORES GUIDO J, TUN GARRIDO J, MERCEDES CRUZ BOJÓRQUEZ M. *Nomenclatura, forma de vida, uso, manejo y distribución de las especies vegetales de la Península de Yucatán*. *Etnoflora Yucatanense* no. 20. Mérida, Yucatán: Universidad Autónoma de Yucatán; 2003.
- ATRAN S. *Cognitive foundations of natural history*. New York: Cambridge University Press; 1990.
- BERLIN B. *Ethnobiological classification*. Princeton (NJ): Princeton University Press; 1992.
- BERLIN EA, BERLIN B. *Medical ethnobiology of the Highland Maya of Chiapas, Mexico: the gastrointestinal diseases*. Princeton (NJ): Princeton University Press. 1996.
- BERLIN B, BERLIN EA. *Prior informed consent and bioprospecting: what does it mean and can it be achieved?* Paper, Vth International Congress of Ethnobiology, Athens, Georgia 2000.
- BERNARD HR. *Research methods in anthropology*. 4th ed. Lanham (MD): AltaMira (Rowman and Littlefield); 2006.
- BERNARD HR, SALINAS PEDRAZA J. *Native ethnography: a Mexican Indian describes his culture*. Newbury Park (CA): Sage; 1989.
- BLACKBURN T, ANDERSON MK, editors. *Before the wilderness: environmental management by native Californians*. Menlo Park (CA): Ballena Press; 1993.
- BLAVASCUNAS E. *The peasant and communist past in the making of an ecological region: Podlasie, Poland*. Ph.D. dissertation, Dept. of Anthropology, University of California: Santa Cruz; 2008.
- BROWN C. *Language and living things: universalities in folk classification and naming*. New Brunswick (NJ): Rutgers University Press; 1984.
- BROWN MF. *Who owns native culture?* Cambridge (MA): Harvard University Press; 2003
- BRUSSELL D. *Potions, poisons and panaceas: an ethnobotanical study of Montserrat*. Carbondale: Southern Illinois University Press; 1997.
- CALLICOTT JB, NELSON MP. *American Indian environmental ethics: an Ojibwa case study*. Upper Saddle River (NJ): Pearson Prentice Hall; 2004.
- CONKLIN HC. *Hanunoo agriculture*. Rome: FAO; 1957.
- CRUIKSHANK J. *Do glaciers listen? Local knowledge, colonial encounters, and social imagination*. Vancouver: University of British Columbia Press; 2005.
- CUSHING FH. *Zuni Breadstuff*. New York: Museum of the American Indian, Heye Foundation; 1920.
- DELCOURT P, DELCOURT H. *Prehistoric native Americans and ecological change: human ecosystems in Native North America since the Pleistocene*. New York: Cambridge University Press; 2004.
- DENEVAN WM. *Cultivated landscapes of Native Amazonia and the Andes*. New York: Oxford University Press; 2001.
- DOOLITTLE W. *Cultivated landscapes of Native North America*. New York: Oxford University Press; 2000.
- ELLEN R. *The cultural relations of classification*. Cambridge: Cambridge University Press; 1993.
- ELLEN R, editor. *Ethnobiology and the science of humankind*. *J Roy Anthropol Inst* 2006; special issue.
- ESCOBAR A. *Territories of difference: place, movements, life, Redes*. Durham (NC): Duke University Press; 2008.

- ETKIN NL, editor. *Plants in indigenous medicine and diet: biobehavioral approaches*. Bedford Hills (NY): Redgrave; 1986.
- ETKIN NL, editor. *Eating on the wild side: the pharmacologic, ecologic, and social implications of using noncultigens*. Tucson: University of Arizona Press; 1994.
- ETKIN NL. *Edible medicines: an ethnopharmacology of food*. Tucson: University of Arizona Press; 2006.
- EVERS L, MOLINA FS. *Yaqui deer songs: Maso Bwikam. A Native American poetry*. Tucson: University of Arizona Press; 1987.
- FELD S. *Sound and sentiment*. Princeton (NJ): Princeton University Press; 1982.
- FELD S, BASSO KH. *Senses of place*. Santa Fe: School of American Research; 1996.
- FELGER R, FELGER MB. *People of the desert and sea: ethnobotany of the Seri Indians*. Tucson: University of Arizona Press; 1985.
- FORD RI. Introduction. In: FORD RI, editor. *Ethnobiology at the millennium: past promise and future prospects*. Anthropological Papers 91, Museum of Anthropology. Ann Arbor: University of Michigan; 2001. p 1–10.
- FRAKE C. *Language and cultural description* (selected by Anwar S. Dil). Stanford (CA): Stanford University Press; 1980.
- FRIEDMANN H. *A bestiary for Saint Jerome: animal symbolism in European religious art*. Washington (DC): Smithsonian Institution Press; 1980.
- GLADWIN T. *East is a big bird*. Cambridge (MA): Harvard University Press; 1970.
- GONZALEZ R. *Zapotec science: farming and food in the Northern Sierra of Oaxaca*. Austin: University of Texas Press; 2001.
- GOULET J-GA. *Ways of knowing: experience, knowledge, and power among the Dene Tha*. Lincoln: University of Nebraska Press; 1998.
- HARBSMEIER C. *Science and civilisation in China. Volume 7, Part 1, Language and logic*. Cambridge: Cambridge University Press; 1998.
- HARPER J. *Endangered species*. Durham: Carolina Academic Press; 2002.
- HARRIS M. *The cultural ecology of India's sacred cattle*. *Curr Anthropol* 1966;7:51–66.
- HARRIS M. *The rise of anthropological theory*. New York: Thomas Y. Crowell; 1968.
- HAYDEN C. *When nature goes public: the making and unmaking of bioprospecting in Mexico*. Princeton (NJ): Princeton University Press; 2003.
- HERDER JG. *Philosophical writings* (translated and edited by Forster MN). Cambridge: Cambridge University Press; 2002.
- HOBBSAWM E, RANGER T, editors. *The invention of tradition*. Cambridge: Cambridge University Press; 1983.
- HUNN E. *The abominations of Leviticus revisited: a commentary on anomaly in symbolic anthropology*. In: ELLEN RF, REASON D, editors. *Classifications in their social context*. London: Academic Press; 1979. p 103–116.
- HUNN E. *The utilitarian factor in folk biological classification*. *American Anthropologist* 1982;84:830–847.
- HUNN E, SELAM J. N'CHI-WANA, the Big River. Seattle: University of Washington Press; 1990.
- HUNN E. *Ethnobotany in four phases*. *J Ethnobiol* 2007;27:1–10.
- HUTCHINS E. *Cognition in the wild*. Cambridge (MA): MIT Press; 1995.
- ISTOMIN K, DWYER M. *Finding the way: a critical discussion of anthropological theories of human spatial orientation with reference to reindeer herders of northeastern Europe and western Siberia*. *Curr Anthropol* 2009;50:29–50.
- KAY CE, SIMMONS RT, editors. *Wilderness and political ecology: aboriginal influences and the original state of nature*. Salt Lake City: University of Utah Press; 2002.
- KITCHER P. *The advancement of science: science without legend, objectivity without illusions*. New York: Oxford University Press; 1993.
- KRONENFELD D. *Plastic glasses and church fathers*. New York: Oxford University Press; 1996.
- LAIRD S, editor. *Biodiversity and traditional knowledge: equitable partnerships in practice*. London: Earthscan; 2002.
- LAMPMAN AM. *Tzeltal ethnomycology: naming, classification and use of mushrooms in the Highlands of Chiapas, Mexico* [PhD dissertation]. Department of Anthropology, University of Georgia; 2008.
- LATOUR B. *Politics of nature: how to bring the sciences into democracy* (translated by Porter C). Cambridge (MA): Harvard University Press; 2004.
- LATOUR B. *Reassembling the social*. New York: Oxford University Press; 2005.
- LEFF E. *Green production: toward an environmental rationality*. New York: Guilford Press; 1995.
- LÉVI-STRAUSS C. *La pensée sauvage*. Paris: Plon; 1962.
- LEWIS W, ELVIN-LEWIS M. *Medical botany: plants affecting human health*. 2nd ed. Hoboken (NJ): John Wiley; 2003.
- LOUV R. *Last Child in the woods: saving children from nature-deficit disorder*. Chapel Hill: Algonquin Books; 2005.
- LOWE C. *Wild Profusion: biodiversity conservation in an Indonesian Archipelago*. Princeton (NJ): Princeton University Press; 2006.
- LOWIE R. *The history of ethnological theory*. New York: Rinehart; 1937.
- MAFFI L, editor. *On biocultural diversity: linking language, knowledge, and the environment*. Washington (DC): Smithsonian Institution Press; 2001.
- MAJNEP IS, BULMER R. *Birds of my Kalam country*. Auckland, NZ: University of Auckland Press; 1977.
- MAJNEP IS, BULMER R. *Animals the ancestors hunted*. Adelaide, South Australia: Crawford House; 2007.
- MARCUS GE. *The sentimental citizen: emotion in democratic politics*. University Park (PA): Pennsylvania State University Press; 2002.
- MARTIN M, MCINTYRE LC, editors. *Readings in the philosophy of social science*. Cambridge (MA): MIT Press; 1994.
- MERTON R. *The sociology of science: theoretical and empirical investigations*. Chicago (IL): University of Chicago Press; 1973.

- MILLER AG, MORRIS M. *Ethnoflora of the Soqotra Archipelago*. Edinburgh: Royal Botanic Garden Edinburgh; 2004.
- MOERMAN D. *Native American ethnobotany*. Portland (OR): Timber Press; 1998.
- NABHAN G. *Gathering the desert*. Tucson: University of Arizona Press; 1987.
- NABHAN G. *Cultures of habitat: on nature, culture and story*. Washington (DC): Counterpoint; 1997.
- NABHAN G. *Where our food comes from: retracing Nikolay Vavilov's quest to end famine*. Washington (DC): Island Press; 2008.
- NAZAREA V, editor. *Ethnoecology: situated knowledge/located lives*. Tucson: University of Arizona Press; 1999.
- NADASYD P. *Hunters and bureaucrats: power, knowledge, and aboriginal-state relations in the southwest Yukon*. Vancouver: University of British Columbia Press; 2004.
- NADASYD P. The gift of the animals: the ontology of hunting and human-animal sociality. *Am Ethnol* 2007;34:25-47.
- NASR SH. *Islamic science: an illustrated study*. Westringham, Kent: World of Islam Publishing Company; 1976.
- PEARSALL D. *Paleoethnobotany*. 2nd ed. New York: Academic Press; 2001.
- PIPERNO D, PEARSALL D. *The origins of agriculture in the Lowland Neotropics*. San Diego (CA): Academic Press; 1998.
- POPPER K. *The logic of scientific discovery*. New York: Basic Books; 1959.
- QUINLAN MB. *From the bush: the front line of health care in a Caribbean village*. Belmont (CA): Thomson Wadsworth; 2004.
- RASMUSSEN K. *Across Arctic America: the narrative of the Fifth Thule Expedition*. Fairbanks: University of Alaska Press; 1999. [Original edition 1927, New York: Putnam.]
- REA A. *At the desert's green edge: an ethnobotany of the Gila River Pima*. Tucson: University of Arizona Press; 1997.
- REA A. *Folk mammalogy of the Northern Pimans*. Tucson: University of Arizona Press; 1998.
- REA A. *Wings in the desert: a folk ornithology of the Northern Pimans*. Tucson: University of Arizona Press; 2007.
- SANGA G, ORTALLI G. *Nature knowledge: ethnoscience, cognition, and utility*. New York and Oxford: Berghahn; 2003.
- SCHREIBER D, NEWELL D. Negotiating TEK in BC salmon farming: learning from each other or managing tradition and eliminating contention? *BC Studies* 2006;150:79-102.
- SCHULTES RE. *Hallucinogenic plants*. Golden Guide. Racine (WI): Golden Press; 1976.
- SCHULTES RE. *Medicines from the earth: a guide to healing plants*. San Francisco: Harper & Row; 1978.
- SCHULTES RE, HOFMANN A. *Plants of the gods: their sacred, healing and hallucinogenic powers*. Rochester (VT): Healing Arts Press; 1992.
- SCHULTES RE, VON REIS S, editors. *Ethnobotany: evolution of a discipline*. Portland (OR): Timber Press; 1995.
- SCOTT JC. *Seeing like a state*. New Haven (CT): Yale University Press; 1998.
- SHIVA V. *Biopiracy: the plunder of nature and knowledge*. Boston: South End Press; 1997.
- SHIVA V. *Protect or plunder? Understanding intellectual property rights*. London: Zed Books; 2001.
- SIMMONS F. *Eat Not This Flesh*. 2nd ed. Madison: University of Wisconsin Press; 1994.
- SOTO LAVEAGA G. *Jungle laboratories: Mexican peasants, national projects, and the making of the pill*. Durham (NC): Duke University Press; 2009.
- STAPP J, WYNDHAM F, ZARGER R, editors. *Ethnobiology and biocultural diversity*. Athens (GA): International Society of Ethnobiology; 2002.
- TOLEDO V. What is ethnoecology? Origins, scope and implications of a rising discipline. *Ethnoecologia* 1992;1:5-21.
- TOLEDO VM. Ethnoecology: a conceptual framework for the study of indigenous knowledge of nature. In: STEPP JR, WYNDAM FS, ZARGER RK, editors. *Ethnobiology and Biocultural Diversity*. International Society of Ethnobiology; 2002. p 511-522.
- TSING AL. *Friction: an ethnography of global connection*. Princeton (NJ): Princeton University Press; 2005.
- TURNER NJ. *The earth's blanket*. Vancouver: Douglas and MacIntyre; Seattle: University of Washington Press; 2005.
- TURNER NJ, THOMPSON LC, TERRY THOMPSON M, YORK AZ. *Thompson ethnobotany*. Victoria, BC: Royal British Columbia Museum; 1990.
- VOGEL JH. *Genes for sale: privatization as a conservation policy*. New York: Oxford University Press; 1994.
- VOGEL JH. *The biodiversity cartel: transformation of traditional knowledge into trade secrets*. [CD.] Quito, Ecuador: CARE; 2000.
- WEBER S. Ancient seeds: their role in understanding South Asia and its past. In: FORD RI, editor. *Ethnobiology at the millennium: past promise and future prospects*. Anthropological Papers 91, Museum of Anthropology. Ann Arbor: University of Michigan; 2001. p 21-34.
- WEBER SA, BELCHER WR, editors. *Indus ethnobiology: new perspectives from the field*. Lanham (MD): Lexington Books; 2003.
- WEST P. *Conservation is our government now: the politics of ecology in Papua New Guinea*. Durham (NC): Duke University Press; 2006.
- WEST P, IGOE J, BROCKINGTON D. Parks and peoples: the social impact of protected areas. *Annu Rev Anthropol* 2006;35:251-277.
- WHITAKER A. *The western hemisphere idea*. Ithaca (NY): Cornell University Press; 1954.
- WILSON GL. *Agriculture of the Hidatsa Indians: an Indian interpretation*. Studies in the Social Sciences 9. University of Minnesota; 1917.
- WIMSATT WC. *Re-engineering philosophy for limited beings: piecewise approximations to reality*. Cambridge (MA): Harvard University Press; 2007.
- WOLF E. Ownership and political ecology. *Anthrop Quart* 1972;45:201-205.
- YETMAN D. *The great cacti: ethnobotany and biogeography*. Tucson: University of Arizona Press; 2007.
- YOON CK. *Naming nature: the clash between instinct and science*. New York: WW Norton; 2009.

Chapter 2

History of Ethnobiology

RICHARD I. FORD

Arthur F. Thurnau Professor Emeritus of Anthropology, University of Michigan, Ann Arbor, MI

THE BEGINNING	15
ETHNOBOTANY	16
ETHNOZOOLOGY	17
STAGES OF ETHNOBIOLOGY	18
STAGE 1. ETHNOECOLOGY	19
STAGE 2. TEK: TRADITIONAL ECOLOGICAL KNOWLEDGE	20
STAGE 3. INDIGENOUS INTELLECTUAL PROPERTY AND RIGHTS	21
CONCLUSION	22
REFERENCES	23

THE BEGINNING

Ethnobiology was first formally defined by Edward F. Castetter at the University of New Mexico (Castetter 1944: 160) as “. . . utilization of plant and animal life by primitive peoples . . .”. His goal was to integrate two well established ethnosciences—ethnobotany and ethnozoology. Both fields began without a name and had ancient antecedents in Asia and the Mediterranean basin. These were the recorded observations of “the other”, cultures that differed from the dominant culture outside urban areas in state-level societies, by explorers, traders, and government officials. Some of the first were in Egypt, China (Anderson 1988), and India, especially of plant and animal medicines and foods (Minnis 2000: 6). Other Europeans reported local plants from colonial areas, and Georg Eberhard Rumphius’ *Herbarium Amboinense* was an influence on Carl Linnaeus during the eighteenth century when developing the biological classification system that became universal in the biological sciences. These biological observations and reports were useful as part of state expansion and colonialism.

In the New World similar records of uses of plants and animals by “the others” were part of a process of familiarization with a new land and its peoples. Columbus started the process,

but other explorers and traders did the same, for example, Champlain, Kalm, Bartram, and the Jesuits (Thwaites 1901). In Mexico Ortiz de Montellano (1990) has documented how natives were brought into formal education by Bernardino de Sahagún and recorded Aztec uses of nature in what is called the *Florentine Codices* (Hunn 2007).

Colonial America witnessed records by the travelers and traders as well as scientific explorers from Europe (Josselyn 1672) and the *intelligentsia* of the colonies (Rush 1774). With the founding of the United States, agents for the new government investigated the continent to assist colonization of new lands. The Lewis and Clark Expedition (Cutright 2003), boundary surveys (Emory 1857; Hunter 1823), and railroad surveys (Wheeler 1889) all included scientists to identify the plants and animals they encountered. Spanish missionaries and agents did the same in Arizona. By the middle of the eighteenth century specialized botanists (Brown 1868; Palmer 1871, 1878), zoologists (Wheeler 1889), and educated adventurers (Powers 1874) were observing the use of nature in the west by Indians. It was only a matter of time before the topics of numerous publications would be codified into distinctive disciplines.

ETHNOBOTANY

Stephen Powers made the first effort by calling the uses of plants by California Indians “aboriginal botany” (Powers 1874). Several others used this term, but in 1895 the botanist John Harshberger coined “ethno-botany” to account for the many uses of plants by ethnographic and prehistoric cultures (Harshberger 1896). Quickly the field was informally defined, although Harshberger did not provide a definition. Some used his spelling (Fewkes 1896) and although a few did not adopt the term (Chestnut 1902), the first PhD in the field was awarded in Chicago in 1900 to David Barrows (1900). The discipline was distinctly American and was mainly utilitarian in focus. By the middle of the twentieth century many Indian tribes had at least one ethnobotany, and a few—Hopi, Navajo, Iroquois—had several (see *Handbook of North American Indians* for tribes and references). At the start of the twentieth century most reports were written by botanists or anthropologists with a botanist to identify the plants (Robbins et al. 1916). A few were produced by Indians (e.g., Parker 1910), and only two by women, Stevenson (1914) and Friere-Marreco.

Ethnobotanical studies in the United States became specialized by topic, and the field expanded as practitioners entered it with different training and interests. Studies about basketry, textiles (Safford 1914), dyes, medicines (Smith 1929), hallucinogens, especially peyote (La Barre 1970), and food plants (Waugh 1914; Yanovsky 1936) appeared. These were topics of anthropological interest.

Before the mid-twentieth century, ethnobotany was a recognized subdiscipline in anthropology. Several Indians published reports (Nequatewa 1933; Tantaquidgeon 1928; Teit 1928), women were prominent, and the majority of the publications now focused on paleoethnobotany (archaeology), which interpreted plant remains based on ethnographic analogy. The main definition of ethnobotany was provided by Jones (1936): “the study of the interrelations of primitive man and plants”. Ethnobotanical plant references for American Indians were so numerous that they formed the basis for two encyclopedic references by Moerman (1986, 1998).

The utilitarian phase of ethnobotany is the international approach to the field with its goal of using the new information about plants to launch economic production in the home country. This reflects the influence Richard Schultes (Schultes and von Reis 1993)

had with his emphasis on “economic botany”. Today there are more ethnobotanists in India than in any other country (Ford 2001: 4).

In the United States academic ethnobotany shifted to plant nomenclature and classification as a way to learn about plants from the natives’ perspectives. Harrington, during his studies of the Tewa speakers in the Southwest, began to recognize the importance of names, their relationships, and the plant characteristics selected to recognize them (Robbins et al. 1916). This detailed linguistic approach was rarely followed until Conklin (1954) carried out Hanunóo work in the Philippines and was quickly followed by Berlin and co-workers (Berlin et al. 1974) and later by students with the highland Maya (Hunn 1977) and in Peru. These linguistic studies allowed generalizations about ethnoclassification (Berlin 1992) and comparative analysis (Brown 1984). The “new ethnography” altered the study of ethnobotanical fieldwork. Ethically, ethnobotanists are expected to gain permission from the local group before commencing research, to have the scope of the work and final products understood by the group, to work in the local language, and to express plant names in the local language as well as by international botanical binomials.

Paleoethnobotany has been very productive with the advent and near universal application of dry sieving of sediment, water, and chemical flotation of soil, pollen analyses, phytolith identification, and wet site plant recovery. These have produced enormous quantities of data which have yielded special insights into the reconstruction of past environments, diets, and lifeways (Pearsall 1996). The same methods and DNA analyses of plant tissue and seeds have enhanced our knowledge of plant management and domestication (Smith 1998; Staller et al. 2006). These are methodological revolutions in comparison to the desiccated plant parts and macro-remains that Volney Jones had to work with when he started the American identification of archaeological plant remains (Griffin 1978; Jones 1936). The topic that has generated the most interest and attention has been the pathway to domesticated plants, using accelerator dating methods on small samples to resolve the chronologies (Smith 1990).

The maturity of ethnobotany as a scientific field is reflected in its professional membership associations and methodological manuals. The professional organizations include the Society for Economic Botany, Culture & Agriculture, the Society of Ethnobotany (India) and the journals *Ethnobotany and Medicine*, *Ethnomedicine*, *Journal of Ethnobiology and Ethnomedicine* (online), *Culture and Agriculture*, *Ethnobotany Research and Applications*, *Journal of Food and Nutrition*, and *Ethnomedizin* (Germany). The standard ethnobotanical methodology is found in Alexiades (1996), Cotton (1996), and Martin (1995). We will later discuss ethnobotany further as an important part of ethnobiology.

ETHNOZOOLOGY

This subdiscipline developed later than ethnobotany but, ironically, the first ethnosciences named was “ethno-conchology” (the study of shell money), as part of this field (Stearns 1889). It is defined as the study of the past and present interrelationships between cultures and the animals in their environment. It includes nomenclature and classification of zoological forms, beliefs about them, and the use of wild and domestic animals. An international component started early because British missionaries and colonial officers were birders (e.g., Sibree 1891). However, as the utilization of animals became part of local ethnographic study, most of the publications in the nineteenth century concerned American Indian tribes (Mearns 1896; Murdoch 1898; Ross 1861).

In the beginning few complete ethnozoologies were published. The exception is the pioneering study of Tewa ethnozoology by Henderson (zoologist) and Harrington (linguist) (1914), who were also to use the term “ethnozoology.” This study lists the animals by order and scientific and Tewa name. It gives the habitat of each and its cultural uses. Two Pueblo studies followed later in the century but neither approached Harrington for thoroughness (Beidleman 1956; White 1947). Several Native American groups have had more comprehensive studies. Malkin (1962) recorded the Seri, and Fradkin (1990) the Cherokee. Another comprehensive study was by Gilmore (1950) who produced a thorough overview of Indian uses of animals on the South American continent. Most studies concentrated on a single zoological order such as mollusks (Harrington 1945), insects (Bodenheimer 1951), reptiles and amphibians (Speck and Dodge 1945), fish (Rostlund 1952), and birds. There are very few local tribal ethnozoology studies.

Ethnozoology moved away from its utilitarian emphasis in research to classification and intellectual interests. Bulmer’s research in New Guinea contributed cultural insight into classificatory research (Bulmer 1967a,b). The ethnozoology monographs published in the past 40 years are very different from those of earlier generations. Students of Berlin well versed in the theory of animal classification wrote dissertations that broke the mold of earlier studies (Anderson 1967; Hunn 1977). Rea (1998, 2007) reported on the Northern Pima in ways that set new standards. Ellen (1993) rephrased the intellectual debate in ethnozoology and showed why religious studies (Douglas 1957) were critical to understanding human–animal relations. Nabhan’s (2003) sea turtle study reveals another example of belief systems and animal appreciation. Ethnozoology is now well integrated into current anthropological theoretical discussions.

Zooarchaeology employs the techniques used by morphological zoologists, comparative anatomical studies, and DNA analyses. The remains are retrieved from sediment with some of same techniques—sieving and flotation—that paleoethnobotanists use. However, the interpretations of the bones do not depend upon ethnographic analogy from published ethnozoology studies (Reitz and Wing 2007). Most are local studies of faunal remains from single sites (Reitz and Scarry 1984) or those in local regions (Cleland 1966). The excavation of sites representing state societies in the Near East and historic United States allowed zooarchaeology to present arguments about past animal care and harvesting, and provisioning urban populations, which are missing from written records (Zeder 1990). The major sub-field of study has been on animal domestication. This was first tackled with morphological examination of bones and then most recently with DNA analyses (Zeder 2006). Europeans have been major contributors to all these studies (e.g., Anthony 2007; Clutton-Brock 1999).

STAGES OF ETHNOBIOLOGY

The ethnobiology discussed at the University of New Mexico in the early twentieth century was not distinctive (Hough 1931). It basically subsumed two existing fields, ethnobotany and ethnozoology. The criticism applies to the ethnobiology program Castetter created there. His definition of the field was a constellation of people–plants–animals (Castetter 1944: 160). The resulting publications were a compilation of biological facts but lacked a paradigm to integrate them, for example, Castetter (1935) and Castetter and Bell (1951). Castetter did recognize the merit of exploring culture to understand the relationships and

for some problems he acknowledged that its explanatory power was greater than a biological perspective. He took a broadside against the emerging field of economic botany as being the commercialization of plants in advanced societies.

Several anthropologists have assessed the history and current status of ethnobiology (Casagrande 2004; Clément 1998; Ford 2001; Hunn 2007). In this paper I acknowledge Hunn's efforts. Ethnobiology is a mature science that is not only the sum of its historic disciplines. It builds upon advances brought to ethnosciences by linguistic analyses of folk classifications and the meaning behind nomenclature. These dimensions introduce it to cognitive anthropology (Medin and Atran 1999). It contributes to the complexity of cultural relations with nature that the other subdisciplines alone did not consider, biological ethics and intellectual property rights.

Stage 1. Ethnoecology (Hunn 2007)

Ecology provides two important principles for the development of an integrating approach to ethnobiology, the concept of the ecosystem, and the biological population as a quantifying variable in ecological models. The ecosystem allows specific, locally named plant and animal species to interact with physical environmental features, for example, precipitation, temperature, etc. Each species in the local ecosystem can be counted. One population, which is central to the ecosystem, is the human population whose dependence on technology and beliefs about the other creatures controls the functioning of the system. Plants and animals are not distinguished by uses or for separate study. Most of the problems addressed by ethnobiology depend upon these central concepts (Moran 1984). Although this approach in anthropology is now passé, it was productive to get the field to the next stage, for example, Rappaport (1967).

Innovative research in ethnology and archaeology has followed these organizing principles. It has directed productive studies in ethnogeography (Hunn 1990) and in complex terrestrial ecosystems (Gomez-Pompa 2003). It introduced innovative ways to examine environmental change (Rea 1983). In archaeology it provided qualitative models to understand past human subsistence by measuring food production and the environmental impact of growing or harvesting sufficient food to keep a human population healthy. Wetterstrom (1986) set the standard with her study at Arroyo Hondo, New Mexico. Styles (1986) used an alternative model in the Illinois Valley. Schoeninger and Spielmann (1986) used geochemical analyses to determine past protein in a Trans-Pecos diet and to hypothesize about what food was missing from prehistoric subsistence. Archaeologists worked to understand human–biological relationships by reconstructing local ecosystems (e.g., MacMahon and Marquardt 2003).

New approaches to ethnobiology resulted from recognizing ecological principles as vital to innovative research and a break with the past for ethnobiology research. Balée (1994) set a challenge for future ethnobotany in Amazonia. Other changes happened in ethnobiology with the recognition of ecosystems. Plants and animals were no longer mere named life forms but also had chemical properties that people need in food and medicine (Kuhnlein and Turner 1991) and spiritual qualities that people revere or fear. As ethnoecology evolved with an emphasis on local populations with needs and problems, applied anthropologists acknowledged that desecration by outsiders should be addressed in order to assist the welfare of local people (Posey et al. 1984). This established a need to understand how Indigenous people managed their resources. Another stage of ethnobiology began.

Stage 2. TEK: Traditional Ecological Knowledge

One of the most salient contributions of ethnobiology has been the recognition and importance of traditional ecological knowledge (TEK). As simple as the concept appears, it is very pervasive when considered relative to contemporary issues such as environmental protection, species preservation, biodiversity, and ecosystem restoration (Cunningham 1999). It is instrumental in changing land use policies like fire management. When the techniques are operational, they demonstrate alternative methods for resource protection different from college natural resource courses. TEK is not a commodity for appropriation or exploitation but environmental processes willingly shared by native people to “protect Mother Earth”.

TEK is part of the local knowledge that is learned in a community (Nazarea 1999). It comes from hands-on participation and first-hand observation reinforced by stories and religious beliefs. This knowledge may be gender limited and distributed according to information networks in the community. The intervention in plant growth or animal distribution varies according to the technological and social techniques available. For plants these may be at different stages in a life cycle—sowing seeds, coppicing shrubs, whipping trees, or digging for roots (Anderson 2005). For animals it may be hunting only in one season or one gender of a species. Applying these methods across a community results in a “domesticated landscape”. If the humans leave, the habitat changes; its configuration is anthropogenic (Deur and Turner 2004).

Fire in the ecosystem is a special case. Natural fires can occur, usually with higher frequency than under the suppression policy after “Smokey the Bear”. Fire was used throughout the world where applicable as a human controlled “tool” for many objectives. By demonstrating that fire is not always destructive and, when targeted and managed, it benefits the ecosystem, K. Anderson (2005) and others have changed local forest management practices in California by the Forest Service. This is a significant admission of ignorance because managers usually regard Indigenous knowledge as superstitious or uninformed and dangerous to implement!

In Benin (tropical Africa) forest access has been contentious. Park rangers have attempted to exclude local people; at the same time professional foresters have demonstrated that in order to maintain the forest structure one needs the people to continue their harvesting practices. Other examples of the benefits of aboriginal management can be shown around the world (Posey and Balée 1989).

Effective conservation and environmental justice have required the saving of appropriate seed for restoration and traditional agricultural practices (Nabhan 1989). It also demands cooperation and the concurrence of local people (Zerner 2000). Native people are involved by practicing *in situ* conservation that allows Indigenous people to manage the plants and their growth in natural contexts (Tuxill and Nabhan 1996).

Biodiversity is impossible to understand without a local human perspective that examines biological knowledge, beliefs, and behavior. Nazarea (1999) has examined the cultural dimensions of biodiversity. Many scientific studies have addressed biodiversity to expose the extent and degree that humans create and maintain diversity, as the authors in Minnis and Elisens (2000) demonstrate throughout North America.

Ecosystem restoration has always posed one intractable problem: restore to what? This is where archaeology digitates with contemporary ethnobiology. The baseline changes depending upon the past date selected. Habitats always endure disturbance and processes of succession renew them. Paleoethnobiology exposes the different seres in a succession

sequence. To account for those stages requires a cultural reconstruction to know the level of cultural complexity and the size of the local population occupying the area under reconstruction. Restoration ecology depends upon one branch of historical ecology that concerns archaeology and paleoenvironmental sciences (Egan and Howell 1999). Pre-agricultural communities had a different environmental signature on the landscape from that of swidden agriculturalists. Delcourt (1999) has demonstrated how environmental sciences can reveal meaningful habitat changes in the same location over time in the eastern deciduous forest.

Unfortunately, in the drive toward modernity, in many areas TEK has been disparaged and rejected. This has been to the detriment of the biotic environment and the wellbeing of local people when preservation of their own ways is beneficial (Hunn 2002). Berkes (1999) shows that peoples' cultural core beliefs are part of TEK.

Stage 3. Indigenous Intellectual Property and Rights

In Stage 2 the ethnobiologist became the student and the "native intellectual" the teacher. This role reversal brings humility and hopefully gratitude to the ethnobiologist. The consequences raise ethical issues, cultural property rights questions, and concerns about Indigenous power in nation states.

The days of "hit and run" ethnobiology are over. In the past ethnobiologists felt a proprietary right to knowledge obtained from native people and a right to their biotic products. Medicine plants could be appropriated (token compensation made it right, converted a resource into a commodity, and a transfer of rights to the possessor). Agricultural plants could be removed to be grown elsewhere with little understanding of future consequences. Medicine plants and knowledge of their efficacy were exportable without community knowledge. Tropical South America was like a candy shop with lots of cheap penny sweets for the taking.

This has changed with the institution of codes of ethics by many professional organizations, agreed to on acceptance of membership. Others are at the corporate level with bioprospecting requiring a fair compensation agreement. Posey (1990) worked during his career to make these agreements fair to Indigenous people and a legal reality. Unfortunately, the possibility that a profitable new drug from an Indigenous source of knowledge will be marketable is remote, and Indigenous people usually get nothing unless there is upfront payment, regardless of results. Problems arise despite good intentions when a nation state insists, often legally, that it receive any compensation and control payments. The International Society of Ethnobiology has been at the forefront of requiring ethical practices and providing good models for proper field conduct. Their Code of Ethics can be found on their website, <http://www.ethnobiology.net>, and is now standard for the field.

Michael Brown (2003) has asked: "Who owns culture?" In the past, without articulating a philosophical argument, ethnobiologists assumed that Indigenous knowledge was individual property to be exploited. Brown examined critical issues about intellectual property disputes and misunderstandings in order to seek a clearer understanding. Riley (2004) and her authors carried the concerns forward by examining legal issues and innovative ways to protect Indigenous property and rights. Ethnobiologists begin research by recognizing and acknowledging Indigenous rights. Interviewing an informant, compensating for time taken, and removing the tapes and notes all with only his/her permission solved the problem. It no longer does. Knowledge generated by an individual might be hers. Other knowledge

is community property no matter who knows it. Songs, sacred artifacts, medicinal formulas, etc. are categories that often are not transferable without proper authority (Brush 1996).

The assertion of Indigenous authority has been fostered by ethnobiologists misbehaving. First, ethnobiologists need to obtain permission from the local community to do fieldwork. Second, they must be upfront about their objectives and procedures. Third, the final product must be understood. Local Indigenous authorities now have the power to restrict research, to redefine a project, or to approve it. They also have the power to initiate research, but on their own terms. For example, lawyers representing tribal interests hired ethnobiologists to conduct research for tribal land claims and these were subsequently published since they already were part of the legal public record, for example, Colton (1974). Native American tribes have sovereignty to contract with ethnobiologists to assist them with land claims and water rights cases. They can dictate the questions for the research and how the results can be used. This does not mean that new information cannot be obtained as part of the research, but it is often an unintended consequence. There is also an effort to train tribal members to do work that outsiders did in the past. With more Native Americans going to college and professional schools, there is a cadre of qualified professionals in some communities. Many are filling archaeology or environmental assessment positions. Native Americans are increasingly writing their own tribal ethnobiologies, for example, Watahomigie (1982) and Salmón (2000).

This new relationship between ethnobiologists and Native peoples poses challenges to applied anthropology. Anthropologists are needed by tribal people but not to implement an externally conceived program of action. The Indigenous people have their own perceived needs and want ethnobiologists to assist them in achieving their goals. These may include reclaiming tribal land, protecting water quality, halting logging, or stopping mining. They may want help in initiating ecotourism or creating archaeological parks.

CONCLUSION

The subjects of ethnobiology today certainly would not be recognized by biological field scientists or anthropologists in 1900. Practitioners of the discipline have made deliberate decisions to explore new directions aiming to preserve its original subjects: Indigenous people and biota. How to do this is the new challenge. Is it simply a philosophical position or is there the political will to achieve this objective at any cost? Ellen (2003) sees the answer as the ultimate test for this relatively new field.

Ethnobiology is dominated by anthropologists in North American and Western Europe. They reflect the directions that professional anthropology is moving in. They are joined and encouraged by organizations of Indigenous peoples worldwide. In other parts of the developing world most ethnobiologists are biological scientists with little social science training. The discipline has made a conscious decision to be international in scope and relevance, but the resolution of these basic philosophical and methodological differences will set the research and political agendas for the discipline. These new directions are unknown.

Trends for the future of ethnobiology have been addressed by many practitioners, for example, Casagrande (2004), Ford (2001), Hunn (2007) and Sillitoe (2004), all of whom express optimism about the future. Most importantly it has been debated by the Ethnobiology Working Group in 2003 sponsored by NSF at the Missouri Botanical Garden and at professional meetings abroad such as the more anthropological International Society of Ethnobiology. Similar conferences and roundtables will provide assessments of new directions for this vibrant field. One concern is that the discipline does not relinquish its

prominence for field studies. Innovative research based upon Indigenous people's comprehension and participation now characterizes the "center of gravity" for ethnobiology, in Castetter's words. Studies like Hunn's recent work in San Juan Gbëë bring distinction to ethnobiology and serve as a model for ethical research by the next generation of students.

REFERENCES

- ALEXIADES MN. Selected guidelines for ethnobotanical research: a field manual. New York: The New York Botanical Garden; 1996.
- ANDERSON EN JR. The ethnoichthyology of the Hong Kong Boat People [PhD dissertation]. Department of Anthropology, University of California; 1967.
- ANDERSON EN JR. The food of China. New Haven: Yale University Press; 1988.
- ANDERSON MK. Tending the wild, Native American knowledge and the management of California's natural resources. Berkeley: University of California Press; 2005.
- ANTHONY DW. The horse, the wheel, and language: how Bronze-age riders from the Eurasian steppes shaped the modern world. Princeton (NJ): Princeton University Press; 2007.
- BALÉE W. Footprints of the forest: Ka'apor ethnobotany—the historical ecology of plant utilization by an Amazonian people. New York: Columbia University Press; 1994.
- BARROWS D. The ethnobotany of the Coahuila Indians of Southern California. Chicago: University of Chicago Press; 1900.
- BEIDLEMAN RG. Ethnozoology of the Pueblo Indians in Historic Times. *SW Lore* 1956;22:5–13.
- BERKES F. Sacred ecology: traditional ecological knowledge and resource management. Philadelphia (PA): Taylor & Francis; 1999.
- BERLIN B, BREEDLOVE D, RAVEN P. Principles of Tzeltal Plant Classification: an introduction to the botanical ethnography of a Mayan-speaking people of the highland Chiapas. New York: Academic Press; 1974.
- BERLIN B. Ethnobiological classification. Princeton: Princeton University Press; 1992.
- BODENHEIMER FS. Insects as human food; a chapter of the ecology of man. The Hague: W. Junk; 1951.
- BROWN R. On the vegetable products, used by the north-west American Indians as food and medicine, in the arts, and in superstitious rites. *Trans Bot Soc Edinburgh* 1868;9:378–396.
- BROWN C. Language and living things, uniformities in folk classification and naming. New Brunswick (NJ): Rutgers University Press; 1984.
- BROWN M. Who Owns Culture? Cambridge (MA): Harvard University Press; 2003.
- BRUSH SB. Is common heritage outmoded? In: BRUSH SB, STABINSKY D, editors. Valuing local knowledge: indigenous people and intellectual property rights. Washington (DC): Island Press; 1996. p 143–164.
- BULMER RNH. Why is a cassowary not a bird? A problem of zoological taxonomy among the Karam of the New Guinea Highlands. *Man* (n.s.) 1967a;2(1):5–25.
- BULMER RNH. Worms that croak and other mysteries of Karam natural history. *Mankind* 1967b;6(12):621–639.
- CASAGRANDE D. Ethnobiology lives! Theory, collaboration, and possibilities for the study of folk biologies. *Rev Anthropol* 2004;33:351–370.
- CASTETTER EF. Ethnobiological studies in the American Southwest I. Uncultivated native plants used as sources of food. *UNM Bull* 1935;4:1–44.
- CASTETTER EF. The domain of ethnobiology. *Amer Nat* 1944;78:158–170.
- CASTETTER EF, BELL WH. Yuman Indian agriculture. Albuquerque: University of New Mexico Press; 1951.
- CHESTNUT VK. Plants used by the Indians of Mendocino County, California. *Contrib US Nat Herbarium* 1902;7: 295–408.
- CLELAND CE. The prehistoric animal ecology and ethnozoology of the Upper Great Lakes region. *Anthropol Paper Mus Anthropol Univ Mich* 1966;29:1–294.
- CLÉMENT D. The historical foundations of ethnobiology (1860–1899). *J Ethnobiol* 1998;18:161–187.
- CLUTTON-BROCK J. A natural history of domesticated mammals. Cambridge: Cambridge University Press; 1999.
- COLTON HS. Hopi history and ethnobotany. In: HERR DA, editor. Hopi Indians. New York: Garland Publishing; 1974. p 279–373.
- CONKLIN HC. The relation of Hanunóo culture to the plant world [PhD dissertation]. Department of Anthropology, Yale University, New Haven; 1954.
- COTTON CM. Ethnobotany: principles and applications. London: John Wiley; 1996.
- CUNNINGHAM AB. Applied ethnobotany: people, wild plant use and conservation. London: Earthscan; 1999.
- CUTRIGHT PR. Lewis and Clark: pioneering naturalists. 2nd ed. Lincoln: University of Nebraska Press; 2003.
- DELCOURT H. Forests in peril, tracking deciduous trees from Ice-age refuges into the greenhouse world. Blacksburg (VA): McDonald & Woodward Publishing; 1999.
- DEUR D, TURNER NJ. Keeping it living, traditions of plant use and cultivation on the northwest coast of North America. Vancouver (BC): University of British Columbia Press; 2004.
- DOUGLAS, M. Animals in Lele religious symbolism. *Africa* 1957;27:46–57.
- EGAN D, HOWELL E, editors. The historical ecology handbook: a restorationist's guide to reference ecosystems. Washington (DC): Island Press; 1999.

- ELLEN RF. The cultural relations of classification. Cambridge: Cambridge University Press; 1993.
- ELLEN RF. Ethnobiology and the science of humankind. Oxford: Blackwell Publishing Limited, 2003.
- EMORY WH. Report on the United States and Mexican boundary survey. Washington (DC): U.S. Government (Cornelius Wendell, printer); 1857.
- ETHNOBIOLOGY WORKING GROUP. Intellectual imperatives in ethnobiology. St. Louis (MO): Missouri Botanical Garden Press; 2003.
- FEWKES JW. A contribution to ethno-botany. *Amer Anthropol* 1896;9:14–21.
- FORD RI. Introduction; ethnobiology at the crossroads. In: FORD RI, editor. *Ethnobiology at the millennium: past promise and future prospects*. *Anthropological Papers* 91, Museum of Anthropology. Ann Arbor: University of Michigan; 2001.
- FRADKIN A. Cherokee folk zoology: the animal world of a Native American people, 1700–1838. New York: Garland Publishing; 1990.
- GILMORE RM. Fauna and ethnozoology of South America. In: STEWARD J, editor. *Handbook of South American Indians*. Volume 6, *Bulletin of the Bureau of American Ethnology* 143; 1950. p 345–463.
- GÓMEZ-POMPA A, ALLEN MF, FEDICK S, OSORNIO J, editors. The lowland Maya area: three millennia at the human–wildland interface. Binghamton (NY): Food Products Press; 2003.
- GRIFFIN JB. Volney Hurt Jones, ethnobotanist: an appreciation. The Nature and Status of Ethnobotany. *Anthropological Papers* 67, Museum of Anthropology. Ann Arbor: University of Michigan; 1978. p 3–19.
- HARRINGTON JP. Mollusca of the American Indians. *Acta Amer* 1945;3:293–297.
- HARSHBERGER JW. The purposes of ethnobotany. *Bot Gaz* 1896;21:146–154.
- HENDERSON J, HARRINGTON JP. Ethnozoology of the Tewa Indians. *Bull Bur Amer Ethnol* 1914; 56.
- HOUGH VA. The bibliography of the ethnobiology of the Southwestern Indians [MA thesis]. University of New Mexico, Albuquerque; 1931.
- HUNN ES. Tzeltal folk zoology: the classification of discontinuities in nature. New York: Academic Press; 1977.
- HUNN ES. N’Chi-Wana, the Big River: mid-Columbia Indians and their land. Seattle: University of Washington Press; 1990.
- HUNN ES. Traditional environmental knowledge: alienable or inalienable intellectual property. In: STEPP JR, WYNDHAM FS, ZARGER RK, editors. *Ethnobiology and biocultural diversity*. Athens: University of Georgia Press; 2002. p 3–10.
- HUNN ES. Ethnobiology in four phases. *J Ethnobiol* 2007;27:1–10.
- HUNTER JD. Manners and customs of several Indian tribes located west of the Mississippi; including some account of the soil, climate, and vegetable productions, and the Indian *Materia Medica*. Philadelphia: J Maxwell; 1823.
- JONES V. The vegetal remains of Newt Kash Hollow Shelter. In: WEBB WS, FUNKHOUSER WD, editors. *Rock-Shelters in Menifee County, Kentucky*. University of Kentucky Reports in Anthropology and Archaeology 3; 1936. p 147–165.
- JOSELYN J. New England rarities discovered. London: G. Widdowes; 1672.
- KUHLEIN HV, TURNER NJ. Traditional plant foods of Canadian indigenous peoples: nutrition, botany, and use. Food and nutrition in human history and anthropology 8. Philadelphia (PA), Gordon and Breach Science Publishers; 1991.
- LE BARRE W. The Peyote cult. Camden (CT): Shoe String Press; 1970.
- MACMAHON DA, MARQUARDT WH. Calusa and their legacy: south Florida people and their environments. Gainesville: University Press of Florida; 2003.
- MALKIN B. *Seri ethnozoology*. Pocatello: Idaho State College; 1962.
- MARTIN G. *Ethnobotany, a methods manual*. New York: Chapman & Hall; 1995.
- MEARNS EA. Ornithological vocabulary of the Moki Indians. *Amer Anthropol* 1896;9:391–403.
- MEDIN DL, ATRAN S, editors. *Folkbiology*. Cambridge (MA): MIT Press; 1999.
- MINNIS PE, editor. *Ethnobotany, a reader*. Norman (OK): University of Oklahoma Press; 2000.
- MINNIS PE, ELISENS WJ. *Biodiversity and native America*. Norman (OK): University of Oklahoma Press; 2000.
- MOERMAN DE. Medicinal plants of Native Americans. Technical Report 19. Museum of Anthropology, University of Michigan; 1986.
- MOERMAN DE. *Native American Ethnobotany*. Portland (OR): Timber Press; 1998.
- MORAN EF, editor. *The ecosystem concept in anthropology*. Boulder (CO): Westview; 1984.
- MURDOCH J. The animals known to the Eskimos of Northwestern Alaska. *Amer Nat* 1898;32:719–734.
- NABHAN GP. *Enduring seeds: Native American agriculture and wild plant conservation*. San Francisco: North Point Press; 1989.
- NABHAN GP. *Singing the turtles to sea: the Comcáac (Seri) art and science of reptiles*. Berkeley: University of California Press; 2003.
- NAZAREA V. *Cultural memory and biodiversity*. Tucson: University of Arizona Press; 1999.
- NEQUATEWA E. Some hopi recipes for the preparation of wild plant foods. *Plateau* 1933;16:18–21.
- ORTIZ DE MONTELLANO BR. *Aztec medicine, health, and nutrition*. New Brunswick (NJ): Rutgers University Press; 1990.
- PALMER E. Food products of the North American Indians. Report to the Commissioner of Agriculture for 1870. Washington, DC: United States Government Printing Office; 1871. p 404–428.
- PALMER E. Plants used by the Indians of the United States. *Amer Nat* 1878;12:593–606; 646–655.
- PARKER AC. *Iroquois uses of maize and other food plants*. Albany: University of the State of New York; 1910.
- PEARSALL DM. *Paleoethnobotany, a handbook of procedures*. 2nd ed. New York: Academic Press; 1996.

- POSEY D. Intellectual property rights and just compensation for indigenous knowledge. *Anthropol Today* 1990;6: 13–16.
- POSEY DA, BALÉE W, editors. Resource management in Amazonia: indigenous and folk strategies. *Advances in Economic Botany* 7. New York: New York Botanical Garden; 1989.
- POSEY DA et al. Ethnoecology as applied anthropology in Amazonian development. *Hum Organ* 1984;43:95–107.
- POWERS S. Aboriginal botany. *Proc Calif Acad Sci* 1874;5: 373–379.
- RAPPAPORT R. *Pigs for the ancestors*. New Haven: Yale University Press; 1967.
- REA AM. *Once a river: bird life and habitat changes on the Middle Gila*. Tucson: University of Arizona Press; 1983.
- REA AM. *Folk mammalogy of the Northern Pimans*. Tucson: University of Arizona Press; 1998.
- REA AM. *Wings in the desert: a folk ornithology of the Northern Pimans*. Tucson: University of Arizona Press; 2007.
- REITZ EJ, SCARRY CM. 1984. Constructing historic subsistence with an example from sixteenth-century Spanish Florida. Glassboro (NJ): Society for Historical Archaeology; 2007.
- REITZ EJ, WING ES. *Zooarchaeology*. Cambridge: Cambridge University Press; 2007.
- RILEY M, editor. *Indigenous intellectual property rights*. Walnut Creek (CA): AltaMira; 2004.
- ROBBINS WW, HARRINGTON JP, FRIERE-MARRECO B. Ethnobotany of the Tewa Indians. *Smithsonian Institution, Bureau of American Ethnology, Bulletin* 55. Washington (DC): Government Printing Office; 1916.
- ROSS BR. An account of the animals useful in an economic point of view to the various Chippewyan tribes. *Can Nat Geol* 1861;6:433–444.
- ROSTLUND E. *Freshwater fish and fishing in North America*. University of California, Publications in Geography 9. 1952. p 1–313.
- RUSH B. *An inquiry into the natural history of medicine among the Indians of North America, and a comparative view of their diseases and remedies with those of the civilized nations*. Philadelphia (PA): American Philosophical Society; 1774.
- SAFFORD WE. Food plants and textiles of Ancient America. *Proceedings of International Congress of Americanists* 19; 1914. p 12–13.
- SALMÓN E. *Iwígara: a Ramámuri cognitive model of biodiversity and its effects on land management*. In: MINNIS PE, ELISENS WJ, editors. *Biodiversity and Native America*. Norman (OK): University of Oklahoma Press; 2000. p 180–203.
- SCHOENINGER MJ, SPIELMANN K. Stability of human diet at Pecos Pueblo during a period of exchange with plains hunter-gatherers. Paper presented at 55th Annual Meeting of the American Association of Physical Anthropologists, Albuquerque (NM); 1986.
- SCHULTES RE, VON REIS S, editors. *Ethnobotany: evolution of a discipline*. Portland (OR): Dioscorides Press; 1993.
- SIBREE J. The folk-lore of Malagasy birds. *Folk-lore* 1891;2:336–366.
- SILLITOE P. Ethnobiology and applied anthropology: rapprochement of the academic with the practical. *J Roy Anthropol Inst* 2004;119–142.
- SMITH HI. *Materia Medica of the Bella Coola and neighboring tribes of British Columbia*. *Natl Mus Canada Bull* 1929;56:47–68.
- SMITH BD, editor. *Rivers of change: essays on early agriculture in eastern North America*. Washington (DC): Smithsonian Institution Press; 1990.
- SMITH BD, editor. *The emergence of agriculture*. New York: Scientific American Library; 1998.
- SPECK FG, DODGE ES. Amphibian and reptile lore of the Six Nations Cayuga. *J Amer Folklore* 1945;58: 306–309.
- STALLER J, TYKOT R, BENZ B, editors. *Histories of maize, multidisciplinary approaches to the prehistory, linguistics, biogeography, domestication, and evolution of maize*. San Diego (CA): Academic Press; 2006.
- STEARNS REC. Ethno-conchology: a study of primitive money. *Annu Rep US Natl Mus* 1889;2(1887):297–334.
- STEVENSON MC. Ethnobotany of the Zuni Indians. *Bureau of American Ethnology, Annual Report* 30. Washington (DC): US Government Printing Office; 1914. p 33–102.
- STYLES BW. Reconstruction of availability and utilization of food resources. In: GILBERT RI JR, MIELKE JH, editors. *The analysis of prehistoric diets*. New York: Academic Press; 1986. p 21–60.
- TANTAQUIDGEON G. *Mohegan medicinal practices, weather-lore and superstitions*. Bureau of American Ethnology Annual Report 43. Washington (DC): US Government Printing Office; 1928. p 264–227.
- TEIT JA. *The Salishan tribes of the western plateaus*. Bureau of American Ethnology, Annual report 45. Washington (DC): US Government Printing Office; 1928.
- THWAITES RG, editor. *Jesuit relations and allied documents*. Cleveland (OH): Burrows Bros; 1901.
- TUXILL J, NABHAN GP. *People, plants and protected areas: a guide to in situ management*. London: Earthscan; 1996.
- WATAHOMIGIE LJ. *Hualapai ethnobotany*. Peach Springs (AZ): Hualapai Bilingual Program, Peach Springs School District Number 8; 1982.
- WAUGH FW. *Iroquois foods and food preparation*. Ottawa: Canada Department of Mines; 1914.
- WETTERSTROM W. *Food, diet, and population at prehistoric Arroyo Hondo Pueblo, New Mexico*. Arroyo Hondo Archaeological Series 6. Santa Fe (NM): School of American Research Press; 1986.
- WHEELER GM. Report upon United States Geographical Surveys west of the one hundredth meridian, in charge of First Lieut. Geo. M. Wheeler... under the direction of the Chief of Engineers, U.S. Army: Published by authority of... the Secretary of War in accordance with Acts of Congress of June 23, 1874, and February 15, 1875. In seven volumes and one supplement,

26 Chapter 2 History of Ethnobiology

- accompanied by one topographic and one geologic atlas. Washington (DC): US Government Printing Office; 1889.
- WHITE L. Notes on the ethnozoology of the Keresan Pueblo Indians. Papers of Michigan Academy of Science, Arts and Letters, Vol. XXXI; 1947.
- YANOVSKY E. Food plants of the North American Indians. United States Department of Agriculture Miscellaneous Publication; 1936.
- ZEDER MA. Feeding cities: specialized animal economy in the ancient Near East. Washington (DC): Smithsonian Institution Press; 1990.
- ZEDER MA. Documenting domestication: new genetic and archaeological paradigms. Berkeley: University of California Press; 2006.
- ZERNER C, editor. People, plants and justice: the politics of nature conservation. New York: Columbia University Press; 2000.

Chapter 3

Ethics in Ethnobiology: History, International Law and Policy, and Contemporary Issues

PRESTON HARDISON

Tulalip Tribes of Washington, Tulalip, WA

KELLY BANNISTER

Director, POLIS Project on Ecological Governance, and Adjunct Professor, Faculty of Human and Social Development, University of Victoria, Victoria, BC

INTRODUCTION	28
HISTORY OF RESEARCH ETHICS AS RELATED TO ETHNOBIOLOGY	30
ETHNOBIOLOGICAL ETHICS AND THE INTERNATIONAL SOCIETY OF ETHNOBIOLOGY	32
INTERNATIONAL LAW AND POLICY DEBATES AND NEGOTIATIONS	35
KEY CONCEPTS, TERMS AND DEFINITIONS	35
UNITED NATIONS TREATIES	38
(I) CONVENTION ON BIOLOGICAL DIVERSITY	38
(II) WORLD INTELLECTUAL PROPERTY ORGANIZATION	39
CONVENTION ON BIOLOGICAL DIVERSITY: INTERNATIONAL REGIME ON ACCESS AND BENEFIT SHARING	39
WIPO INTERGOVERNMENTAL COMMITTEE ON GENETIC RESOURCES, TRADITIONAL KNOWLEDGE AND FOLKLORE (IGC)	41
CONTEMPORARY ISSUES FOR ETHNOBIOLOGISTS	43
REFERENCES	47

Ethical questions in ethnobiology and other fields that engage communities or draw on community knowledge as the focus of study are some of the most difficult and intractable considerations researchers may face in their careers. Difficulties can arise from several

directions, such as differing principles and values, conflicting obligations, insufficient understandings, unmet expectations, and the general complexity of working in real-world situations. Dominating all of these considerations is that, like anthropology, in ethnobiology “the subject of study stares back”.

A well known context for raising ethical issues in ethnobiology is the practice of bioprospecting based on traditional knowledge¹ of Indigenous and local peoples.² Over the last couple of decades, traditional knowledge related to biological diversity and genetic resources has been sought after by government, academic and industrial researchers to identify leads for the development of new drugs, healthcare products, health foods, and other useful consumer goods. Particularly when commercial exploitation is involved, bioprospecting and other acts of taking and using traditional knowledge beyond the cultural context where it originated have become increasingly complex and contested on both ethical and legal grounds. A spectrum of views exists. At the extremes, proponents (largely within academe, government, and the private sector) argue that scientific validation and exploitation of traditional knowledge related to biodiversity and genetic resources will bring prestige and economic opportunities to Indigenous and local communities and/or national governments of “developing” countries, offer new products and other advancements to wider society, and create incentives for the conservation of disappearing ecosystems. Opponents argue that knowledge and resources are being “stolen” from Indigenous and local communities (i.e., biopiracy), eroding their cultures and the ecosystems upon which they depend, interfering with cultural responsibilities (e.g., to past and future generations), and undermining Indigenous rights to traditional resources, intellectual property, and biocultural heritage (Bannister and Solomon 2009a). As will be discussed later in this chapter, the complex of ethical, legal, political, and ecological issues revolving around the use, misuse, and commodification of traditional knowledge was and continues to be a key catalyst in the development of ethical guidance for ethnobiologists worldwide.

This chapter first provides historical background on applied ethics and describes the emergence of ethical standards within the field of ethnobiology. It then focuses on the current international policy context for ethical and related legal issues raised and perpetuated by biocultural research in ethnobiology. It concludes with a summary of contemporary issues and suggestions that today’s ethnobiologists and others working in a biocultural context arguably have an ethical obligation to become informed about and consider carefully in negotiating the many potential dilemmas and sensitivities of working with traditional knowledge and associated living cultural heritage.

INTRODUCTION

In the simplest sense, ethics is how we treat one another. The word *ethics* comes from the Greek work *ethos*. Earliest uses were geographic, referring to an “accustomed place” or abodes of animals, plants, and men (Skeat 1963). The idea of *ethos* as a place or local environment to which one was accustomed came to embrace the local customs

¹There is no single agreed definition of traditional knowledge and it is beyond the scope of this chapter to enter into the longstanding debate on a definition. The term refers generally to the knowledge, traditions and innovations of Indigenous and local peoples, and is used here in accordance with common usage in international environmental law (e.g., Convention on Biological Diversity).

²As discussed subsequently, the term “Indigenous and local peoples” has no single agreed definition. In this chapter the term is used in accordance with international human rights law (e.g., ILO 169).

and habits, or *mores*, of places. In other words, the concept shifted from describing the character of a place to the moral character of the people inhabiting that place (Liddell and Scott 1940).

Today, ethics has several meanings. It is used as a synonym for *morality*, wherein morality is seen as largely inherent in cultures and societies. For example, “do not harm others” and “do not lie” are part of the set of moral standards shared by most members of a culture or society, referred to as “common morality”. The relationship of ethics to morality is debated by philosophers, some treating both as equivalent terms coming from the same root words for “custom”, others figuring ethics as a subset of morality, and still others seeing morality as a subset of the broad ethical question of “How should I live?” (Downie 2005; Williams 1985). Ethics is also an academic field of inquiry within philosophy that subjects commonly accepted moral beliefs and customs to rational critique. Philosophers have elaborated numerous ethical theories that provide frameworks for evaluation of moral judgments, moral character, and acceptability of actions.

More generally, ethics can be thought of as inquiry into moral decision making which attempts to sort out right and wrong, benefits and harms of human action (and inaction), and moral obligations to others. Ethics, in this sense, is about seeing problems and enacting mechanisms, such as frameworks of principles and guidelines, to allow address of those problems.

When there is no law at risk of being broken, most people tend to weigh their actions under certain circumstances and in light of potential outcomes. An ethical dilemma occurs when it is not clear what we ought to do in a given situation, such as when negative consequences result from seemingly ethical actions; when actions are inconsistent with one’s moral or religious beliefs; or when there is a sense of conflicting obligations to do the right thing.

General scientific ethics and standards for responsible research conduct are well established, largely defining and perpetuating the institution of science, especially as an academic endeavor. These fundamental principles and their implementation include:

- Reproducibility and scientific validity, which rely on defined methods for experimentation and treatment of data;
- The integrity of the scientific process, which requires avoiding bias and conflicts of interest;
- The quality of science, which depends on sharing knowledge through publication and openness;
- Proper attribution in citing other’s work and in determining authorship, which are essential mechanisms for credit and accountability; and
- Ethical treatment of human participants in research (National Academy of Sciences 1995).

Unintentional errors or negligence in the above are largely mediated by mechanisms such as peer review, while scientific misconduct, particularly deception (i.e., fabrication, falsification, or plagiarism), is seen as antithetical to scientific values, with severe consequences.

General scientific ethics are built upon the pursuit of knowledge as a fundamental value. They go beyond common morality, but do not provide any contextual guidance for researchers within their field of specialty. This may be adequate for some sciences but not for others. An additional layer of ethics is particularly important for research that is directly engaged with the social world, where unintended consequences may arise as result of

people, communities, or cultures being subjected to a focused inquiry. Likewise, there are ethical considerations (e.g., access, species conservation) in studying the biological world. Ethnobiology, as a discipline that focuses on the cultural and biological interface, requires a comprehensive and integrated assessment of ethics applied to both the social and biological realms.

HISTORY OF RESEARCH ETHICS AS RELATED TO ETHNOBIOLOGY

Ethics emerged as an applied academic discipline in the 1960s and 1970s as academics and professionals from a variety of backgrounds began to question some of the assumptions of their disciplines in the face of new observations and some deeply troubling revelations, particularly relating to technological advancement, sustainable development, human and environmental health, and human rights. Some of these concerns included accelerated technological change and threats from technology (e.g., nuclear armaments, Three Mile Island), and massive expansion of industry and pollution based on advances in science [e.g., Rachel Carson's (1962) *Silent Spring*], including critique of the Green Revolution (Brush 1992; Clawson and Hoy 1979; Conway and Barbier 1990; Shiva 1989). Anthropologists, geographers, development practitioners and others in the 1970s and 1980s called into question many of the assumptions of dominant development models of the time, which focused on economic and technological development (Blunt and Warren 1996; Chambers 1979; Chambers et al. 1989; Escobar 1991; Johannes 1978; Peluso 1992). Their studies uncovered the persistence, resilience, and fundamental importance of contributions of traditional knowledge, technologies, and lifestyles to human development, wellbeing and livelihoods.

A common theme was that the dominant development models failed to take into account market externalities (or market failures) and distributive justice. Market externalities occur when there are spillover impacts of economic transactions onto others who are not directly involved in the transactions. Externalities may be either positive, such as when others may benefit from the wildlife that are maintained in intact habitat on private lands, or negative, such as when pollution created in the manufacture of consumer goods drifts across borders to harm others who neither manufactured, consumed, or otherwise benefitted from the transaction. These negative spillovers created ethical problems related to the unequal distribution of both the benefits and the harms of development, known as distributive justice problems.

Another set of disturbing events was the uncovering of secret histories of medical and military experimentation on humans, including among others: (i) the Tuskegee Syphilis Study (1932–1972), which charted the effects over 40 years of untreated syphilis on males of African-American descent, many of whom were recruited for the study and intentionally infected with syphilis without their knowledge, then denied treatment based on their participation (Jones 1981; Tuskegee University 2010); and (ii) atrocious human experimentation on concentration camp prisoners in Nazi Germany during the 1940s in World War II, leading to the Nuremberg Doctors Trial and a judgment by the war crimes tribunal which established a new standard for ethical medical experimentation on humans that became accepted worldwide, called the Nuremberg Code (Mitscherlich and Mielke 1949). Both the Tuskegee and Nuremberg cases heavily influenced the development of international standards for biomedical research. Key ethical principles included voluntary informed consent of the participant, weighing of risk against expected benefit, and ensuring participants can withdraw from a study without consequence. These core principles have been elaborated on and expanded over the last couple of decades and are still embodied in contemporary

ethical standards for all research involving humans in north America, including the *Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research* in the United States (National Commission 1979) and, in Canada, the *Tri-Council Policy Statement: Ethical Guidance for Research Involving Humans* (CIHR et al. 1998) as well as the Canadian Institutes for Health Research (CIHR) *Guidelines for Health Research Involving Aboriginal People* (CIHR 2007). An extensively revised second edition of the *Tri-Council Policy Statement* is anticipated by early 2011, containing two new sections highly relevant to ethnobiology on Aboriginal Research and Qualitative Research.

An additional influence on contemporary research ethics is the controversy that emerged over the alleged role of anthropologists in gathering military intelligence under the guise of social sciences research during wartime, such as Project Camelot in Chile (1964) and the Vietnam War (1955–1975). The issues raised by these controversies put social science research under public scrutiny and influenced the eventual development of a Code of Ethics by the American Anthropological Association (1998) to provide guidelines for making ethical choices within the complex situations within which anthropologists may be conducting their work (Hill 1998).

Following this period, ethics increasingly referred to codified standards of behavior for researchers and professionals (e.g., biomedical ethics, environmental ethics, legal ethics, human research ethics, animal care ethics), which began to emerge as codes of ethics, codes of conduct, and research protocols of various forms. Today a vast amount and diversity of ethical guidance exists and continues to be developed by academic societies and professional associations, non-governmental organizations, Indigenous organizations, and Indigenous and local communities, as these groups increasingly seek to clarify their ethical stances and codify guidance to others with the intent of fostering ethical, equitable, and productive working relationships.³

Another important strand in the historical evolution of ethical standards for ethnobiology is the Indigenous rights movements of the 1970s. While the first organized international movements of Indigenous peoples date back to around 1900 in North America and Scandinavia, more stable international networks came much later, with the most dramatic gains in institutionalizing Indigenous rights related to biocultural knowledge in the international arena occurring over the last couple of decades. The first international standard specifically devoted to Indigenous rights was the International Labor Organization's (ILO) *Indigenous and Tribal Peoples Convention 169* (adopted in 1957 and revised in 1989). While ILO 169 is considered to be limited in scope, it continues to be a key international legal instrument on Indigenous rights to self-determination, cultural and spiritual values, practices, and institutions (discussed in a later section). The most recent advancements include the *United Nations Declaration on the Rights of Indigenous Peoples* (General Assembly 2007) and the establishment of a Permanent Forum on Indigenous Issues in 2000. The *Declaration* addresses the rights of Indigenous peoples in respect

³Many diverse examples exist and are available online, ranging from codes of ethics of academic and professional societies (e.g., Code of Ethics of the American Anthropological Association 1998; Guidelines of Professional Ethics of the Society for Economic Botany 1995; International Society of Ethnobiology 2006), to research guidelines and protocols developed by Indigenous communities (e.g., Akwesasne Good Mind Protocol 1995; Mi'kmaq Research Principles and Protocols 2000; Protocols and Principles for Conducting Research in a Nuu-Chah-nulth Context 2004; Six Nations Council Ethics Committee Protocol), to ethical codes and guidelines developed by Indigenous organizations for projects involving Indigenous peoples (e.g., Alaska Federation of Natives Guidelines for Research 1993; Traditional Knowledge Research Guidelines: A Guide for Researchers in the Yukon 2000), to name only a few.

of self-determination, culture and language, land and resources, environment and development, intellectual and cultural property, Indigenous law and treaties, and agreements with governments, among other things. The Permanent Forum on Indigenous Issues was established by the United Nations Social and Economic Council to serve as an advisory body to the Council on Indigenous issues related to economic and social development, culture, the environment, education, health, and human rights (Bannister and Solomon 2009b; UNPFII website).

Within international Indigenous rights instruments, protection of traditional knowledge is viewed as integrally linked to self-determination, since knowledge appropriation and commodification tend to be viewed broadly as related to human and land rights, as well as potential involving intellectual property and cultural heritage rights. It is important to note, however, that framing traditional knowledge as intellectual property is more a reflection of Eurocentric institutions than of Indigenous peoples. For many Indigenous peoples, “protection” of their traditional knowledge systems within an intellectual property legal framework is an alien concept. Indeed, this apparent contradiction inspired the promotion of “traditional resource rights” by the late Darrell Addison Posey and colleagues (Posey and Dutfield 1996) as an integrated rights concept that is guided by human rights principles and recognizes the inextricable links between cultural and biological diversity.

By the early 1990s, largely stimulated by the intensive bioprospecting efforts of academic–industrial partnerships and resulting claims of biopiracy, legal protection of traditional knowledge, and issues of permission, credit and financial compensation for use of traditional knowledge became topics of contentious international debate at the intersection of international environmental and human rights law, and launched a concerted effort by the International Society of Ethnobiology to develop ethical guidance for ethnobiologists (Bannister and Solomon 2009a).

ETHNOBIOLOGICAL ETHICS AND THE INTERNATIONAL SOCIETY OF ETHNOBIOLOGY

In 1988 the First International Congress of Ethnobiology was organized in Belém, Brazil by the late Darrell A. Posey and colleagues. Posey, who had started his career focusing on ethnoentomology and traditional resource management by the Kayapó of Brazil, had come to see the value of traditional knowledge and resource management systems as crucial to implementing the emerging concept of sustainable development. He also recognized the need for a coming together of diverse actors to tackle the complex and pressing issues at stake. The congress resulted in the founding of the International Society of Ethnobiology (ISE), which was established as an umbrella organization through which scientists, environmentalists, and Indigenous peoples could work together to protect the world’s endangered biological and cultural diversity.

At the time of Posey’s work, the Kayapó were, and continue to be, galvanized in struggles against government projects to build large hydroelectric dams along the Xingu River and other rivers in the Amazon Basin. Many Indigenous peoples at the time were also protesting the use of their traditional knowledge and cultural resources without their permission and without compensation. Posey advocated going beyond ethical obligations set out by research institutions and academic societies at the time to include issues related to human rights. The 600 delegates from 35 countries, including representatives from 16 Indigenous organizations who participated in the first Congress joined together in the

Declaration of Belém, supporting the notion that “all other inalienable human rights be recognized and guaranteed, including cultural and linguistic identity” (International Society of Ethnobiology 1988; Article 3).

The *Declaration of Belém* also explicitly recognizes the continuing destruction of ecosystems throughout the world, and its devastating biological and human implications. Recognizing that the knowledge underlying the resource management practices of the world’s Indigenous peoples is directly tied to the maintenance of biological diversity, the *Declaration of Belém* underscores the point that loss of traditional knowledge is inextricably linked to loss of biological diversity and *vice versa*. The *Declaration of Belém* was the first international declaration to call for mechanisms to be established to recognize and consult with Indigenous specialists as proper authorities in all activities affecting them, their resources, and their environments, and that procedures be developed to compensate Indigenous peoples for use of their knowledge and their biological resources (ISE website).

Throughout the rest of his career, Posey continued to press for the recognition of Indigenous rights, challenging ethnobiologists to develop higher levels of awareness and commitment to respect and protect Indigenous rights and cosmologies in research. Recognizing the role of ethnobiologists as intermediaries between scientific and Indigenous cultures, and how academic data often flow into the private sector for commercial purposes, Posey argued that a lack of relationship between researchers and holders of traditional knowledge can facilitate not only commodification of the knowledge but of the sacred: “the plant, animal, or crystal that an ethnopharmacologist wants to collect may, in fact, encompass, contain, or even be the manifestation of an ancestral spirit—even the healer’s grandmother” (Posey 2002).

Posey’s work catalyzed a new wave of intellectual and political debate on the ethics of research related to biocultural diversity, and laid the foundation for reconceptualizing issues of appropriation of traditional knowledge, from local to international levels. Using the *Declaration of Belém* as a foundational set of principles, Posey established an Ethics Committee under the ISE in 1992 with a specific mandate to develop a Code of Conduct for the Society. Until his death in 2001, Posey led an extensive process of open hearings, working sessions, discussion, and debate involving hundreds of people from all parts of the world and including Indigenous and non-Indigenous scholars, professionals, activists and practitioners. Over a decade later, after extensive drafting and redrafting that also involved a thorough assessment of many existing codes, guidelines, and research protocols as well as key issues arising within relevant international policy fora, the final version of the ISE Code of Ethics was unanimously adopted by the ISE membership at the Tenth International Congress of Ethnobiology in Chiang Rai, Thailand in 2006 (with an amendment in 2008 to include an Executive Summary and Glossary of Terms).

The ISE Code of Ethics consists of a preamble, purpose, 17 principles, and 12 practical guidelines. It is founded on the value of “mindfulness”, described as “a continual willingness to evaluate one’s own understandings, actions, and responsibilities to others” (ISE 2006).

The ISE Code of Ethics is characterized by a number of progressive principles that expand on contemporary research ethics standards and draw on international human rights and environmental law in a way consistent with Posey’s visionary direction.

- Indigenous prior proprietary rights and cultural responsibilities are explicitly acknowledged.

- Active community participation in all stages of research from inception to implementation and interpretation are encouraged.
- The concept of “educated prior informed consent” is promoted, which recognizes informed consent not only as an ongoing process but as requiring an educative component that employs bilingual and intercultural education methods and tools to ensure understanding by all parties involved.
- The precautionary principle is supported through promoting proactive, anticipatory action to identify and to prevent biological or cultural harms resulting from research activities or outcomes.
- Researchers are expected to incorporate reciprocity, mutual benefit, and equitable sharing in ways that are culturally appropriate and consistent with the wishes of the community involved.
- Research is viewed as a cycle of continuous and ongoing communication and interaction, which should not be initiated unless there is reasonable assurance that all stages can be completed.
- Supporting Indigenous communities in undertaking their own research based on their own epistemologies and methodologies is a priority.
- The importance is underscored of acknowledgement and due credit in accordance with community preferences in all agreed outcomes (e.g., publications and educational materials) including co-authorship when appropriate, and extending equally to secondary or downstream uses and applications such that researchers will ensure that connections to original sources of knowledge and resources are maintained in the public record.
- Research is expected to be conducted in the local language wherever possible, which may involve language fluency or employment of interpreters.
- Researchers are also expected to have a working understanding of the local context prior to entering into research relationships with a community, which includes knowledge of and willingness to comply with local governance systems, cultural laws and protocols, social customs, and etiquette (above list excerpted from Bannister and Solomon 2009a: 157–158).

The principles underscore additional layers of duty that compel researchers to be concerned about the dignity and autonomy of individuals, as well as that of the communities involved and affected. Ethical duty is also extended beyond humans to include the surrounding environment upon which humans depend, acknowledging rights and obligations to both living and non-living, across past, present, and future.

Importantly, the ISE Code of Ethics represents a widely accepted standard internationally, which is explicitly meant to support and enable but *not supersede* community-level processes and structures:

This Code of Ethics recognizes and honors traditional and customary laws, protocols, and methodologies extant within the communities where collaborative research is proposed. It should enable but not over-ride such community-level processes and decision-making structures. It should facilitate the development of community-centered, mutually-negotiated research agreements that serve to strengthen community goals.

The ISE Code of Ethics offers guidance on key issues that are under debate in international law and policy fora in relation to appropriation of traditional knowledge. In particular, these include prior informed consent (PIC), mutually agreed terms (MAT) including benefit sharing, capacity-building, recognition of customary laws, and underscoring the vital role of community research protocols in changing research practice, including shifting the power dynamics of decision making and likely requiring more formal processes and agreements to lay out the goals and terms of research as mutually defined with source communities and traditional knowledge holders. This will be discussed in a subsequent section.

INTERNATIONAL LAW AND POLICY DEBATES AND NEGOTIATIONS

Key Concepts, Terms and Definitions

As noted previously, over the past quarter-century Indigenous peoples and local communities have not only been of increasing interest to anthropologists and others, but also have become the subject of international law. From the founding of the League of Nations in 1920, and continuing with the founding of the United Nations in 1945, groups began petitioning the international legal system to recognize their human and political rights, including the political right to self-determination (Mauro and Hardison 2000).

The right to political self-determination for groups within national boundaries is recognized in many countries of the world. These groups go by many names, including tribes, Indigenous, local community, Aboriginal, Native, and First Nation. There is no single concise definition for any of these terms, and there exist numerous legal and academic treatments. As the international legal system took up this issue and began to address its complexities, it settled on the term “*Indigenous*” as a common way to refer to these groups.

The most common and influential definition of Indigenous is found in ILO’s *Indigenous and Tribal Peoples Convention 169* (ILO 169), originally adopted in 1957 and revised in 1989. ILO 169 recognizes tribal and Indigenous groups as distinct peoples. It does not define Indigenous and tribal peoples, instead providing a list of elements to guide nation states in their identification. Elements common to both tribal peoples and Indigenous peoples are that they possess: (i) traditional life styles; (ii) a culture and way of life different from the other segments of the national population, for example, in their ways of making a living, language, customs; and (iii) their own social organization and traditional customs and laws (ILO 2003). Additionally, Indigenous peoples are those who have been living in historical continuity in a certain area, or before others “invaded” the area (ILO 2003). ILO 169 considers self-identification and the collective desire to remain as distinct peoples to be the leading criteria.

The use of plural “*peoples*” is critical and the designation was hard fought internationally by Indigenous groups and others. In the United Nations system, all nation states are considered to be ruling bodies that collectively represent their peoples, and which possess sovereignty, self-determination, and the right to govern and set rules for their citizens. A *sovereign* has the power to grant, withhold, and distribute rights among citizens. Governments commonly refer to this process as balancing rights among stakeholders. A sovereign does not have the right to govern or make laws for other peoples, or to balance

the rights of their citizens against citizens residing in other countries. Sovereigns make agreements on behalf of their peoples in a number of different ways, including declarations, agreements, conventions, and treaties. *Declarations* are aspirational documents, although they may contain elements of codified and customary international law, and set a direction for the elaboration of international law over the long term. *Agreements* are binding documents made between two or more states, usually involving a narrow issue. *Conventions* and *treaties* are highly formal, larger scale agreements involving many issues. Through these different instruments, sovereigns come to agree on cooperative actions and voluntarily limit the exercise of their sovereign powers. Sometimes these limits are considered to be universally binding, or *erga omnes* norms (Latin: “applying to all”), such as laws related to human rights (e.g., the prohibition against genocide). At other times, any limits are seen as strategic and voluntary.

Two other distinctions are helpful in understanding international law. The first is the distinction between “soft law” and “hard law”. These occur on a continuum, and treaties usually contain elements that cover the whole spectrum. *Soft laws* are measures (e.g., policy statements, principles, guidelines), aspirations which those agreeing to a treaty (the “parties”) have agreed to move towards in a process of progressive implementation. *Hard law* takes the form of binding the parties to specific actions, which they agree to implement in a reasonable amount of time after ratifying the treaty. These actions may be accompanied by sanctions or penalties.

The importance of this discussion for ethnobiologists is the observation that a large percentage of the groups and individuals informing ethnobiological research are now the subject of international law, and are increasingly acknowledged to possess considerable political rights to self-determination. The international system is setting out principles that lead national governments to take measures in their national legal systems to recognize and implement these rights. Indigenous rights to lands, waters, sacred places, biodiversity, genetic resources, and traditional knowledge are increasingly being recognized in national constitutions, statutes, agreements, policy, administrative rulings, memoranda, executive orders, statements of understanding, protocols, and other instruments as part of a national hard law and soft law.

The recognition of Indigenous sovereignty and self-determination is well advanced in a number of nations, particularly in those nations known as settler states, in which there was a clear initiation of a phase of colonization that separated prior inhabitants from the colonizers, such as in Latin America and Caribbean, Australia, Canada, New Zealand, and the United States. In New Zealand, the United States, and some of Canada, the colonizers signed treaties with the inhabitants, an instrument used for agreements between nations.

These developments provide a rich ground for analysis from an ethnological point of view. At the international level, the legal system has begun to construct a legal regime that applies the concept of Indigenous to an extremely diverse group of cultures with different histories and forms of political, social, and economic organization—estimated at over 10,000 distinct groups, with 370 million people in 70 countries (UNPFII 2010). Some of these peoples are nomadic, some are dispersed in tropical forests with little political organization, while others, such as the Quechua and Aymara in the Andes, number in the millions. Many governments of Africa, however, do not recognize Indigenous peoples, but instead refer to “local communities”. In these governments’ view, they are “all Indigenous to Africa” (Henriksen 2008).

The legal movements described above draw from explicit principles contained in existing international legal instruments, known as international customary law. They are

also entering new ground where there is little precedence. Where the law is confronted by new situations, it turns to create *sui generis* law (Latin: “of its own kind”), or law that is unique. Much of United Nations human rights law, as well as national law in modern democracies, focuses on the rights of individuals. In contrast, Indigenous rights are characterized as collective rights. Anthropologists have pointed to the complex nature of collective systems, and have developed a number of concepts to describe them, such as commons, common property systems, communal systems, and collective resource management systems. Although there is no single Indigenous position on these concepts, they are disputed by some Indigenous activists, academics, politicians, and communities, who use counter-naming strategies to develop and apply their own concepts and epistemologies.

To cite one example, some Indigenous scholars reject the use of the terms *cultural property* and *cultural resources*. They believe these concepts reflect the materialism of the West, which isolates living processes and relationships in nature that have a spiritual basis to create material objects that can be commodified, alienated, dispassionately managed, privatized, and sold in the market (Farhata 2008). One initiative at the international level attempts to introduce the concept of *collective bio-cultural heritage*, which refers to the holistic dimension of traditional knowledge inseparable from nature, and is based on balance, reciprocity, and duality (Swiderska 2008). Along with other Indigenous representatives, these authors reject the ability of existing Western legal systems, such as the intellectual property rights (IPR) system, to protect their rights, lands and heritage. Other Indigenous scholars disagree, believing that Indigenous epistemology can find a path to expression and that, with proper modification and the elaboration of *sui generis* law, protections can be found within Western legal systems (Carpenter et al. 2009).

It is for the reader to pursue the details of the arguments set out above and draw his/her own conclusions—the purpose here is not to settle the disputes, but to point out that the elaboration of a collective rights regime that can effectively address the concerns of millions of different Indigenous peoples involves some very difficult conversations between groups with very different ideologies, orientations and worldviews, and will remain sites of cultural contestation. These struggles do not only involve Indigenous peoples against the state. They also involve struggles among Indigenous peoples themselves over the future of their societies, and with those who make claims of Indigeneity in an attempt to capture the rights to resources, lands, and protections offered by the new laws (Li 2010).

International treaties are negotiated in diplomatic contexts. They may take decades to negotiate. They are, by their nature, extremely conservative and abstract processes. Because they intend to promote or establish law, they have to work within the constraint of developing and using concepts that can be understood by all of the state representatives and be accepted by consensus. Consensus in this case is not majority vote, but a process where principles, language, and commitments are only accepted when no one objects. Because of this, international law often remains at the level of principles and guidelines, and leaves out much of the ethnographically rich detail of laws at the national and local level. International law is not a “magic bullet” that can slay bad actors on the international stage by laying out detailed instructions on rightful behavior and force states into compliance. A few treaties have criminal provisions that allow for sanctions and penalties. More often, treaties work by promoting the development of national laws that fulfill their intentions. Once a treaty is ratified, much work must still occur domestically, and those engaging in these processes must be prepared to work at multiple levels with strategies appropriate for each case.

United Nations Treaties

There are few treaties that have any detailed provisions related to traditional knowledge and biological resources. After more than 25 years of negotiation, the United Nations General Assembly adopted the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) on 13 September 2007 in a pivotal moment for the recognition of the collective rights of self-determination of millions of marginalized peoples. In 41 articles, the *Declaration* sets out a broad range of rights to possess, control, participate, and make decisions over diverse sectors such as education, spirituality, traditional knowledge, lands, waters, and genetic resources; rights to be free of coercion, dispossession, or eviction; and to have these rights recognized by the wider societies in which they are embedded.

Although the *Declaration* is the touchstone of principles for nations to carry into national laws, policies, and ethical guidelines, it is not a treaty. Two treaties are currently being negotiated (as of August 2010), that if completed will likely contain internationally binding commitments that will affect ethnobiological research, as they contain provisions related to traditional knowledge, biodiversity, and genetic resources:

(i) Convention on Biological Diversity

The Diversity (CBD) treaty entered into force in 1993. The three main objectives of this convention are: (a) conservation of biological diversity; (b) sustainable use of its components; and (c) fair and equitable sharing of the benefits arising out of the utilization of genetic resources. It was the first international treaty to contain substantial provisions relating to Indigenous peoples, containing Article 8(j), which states:

Subject to national legislation, respect, preserve and maintain knowledge, innovations and practices of Indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge innovations and practices.

United Nations Environment Program 1993

In 2000 the CBD began negotiating the *International Regime on Access and Benefit Sharing* (ABS), scheduled to be completed by October 2010. The draft treaty addresses issues specifically related to genetic resources, and includes legal provisions on traditional knowledge and associated genetic resources. In addition, states adopted the voluntary *Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization* (Bonn Guidelines), a precursor to the ABS, but which still remains a useful source of measures that can be adopted nationally and locally (SCBD 2002). The Convention is also considering the adoption of the *Tkarihwaïé:ri Ethical Code of Conduct on Respect for the Cultural and Intellectual Heritage of Indigenous and Local Communities Relevant for the Conservation and Sustainable Use of Biodiversity* (Tkarihwaïé:ri is taken from the Mohawk, and means the “proper way”; SCBD 2009). These ethical guidelines are designed to work in the same way as the Bonn Guidelines, to provide a set of ethical principles for collaborating with Indigenous peoples that can shape both the law and ethical climate of nations. The CBD has also adopted the *Akwe: Kon Voluntary Guidelines for the Conduct of Cultural, Environmental and Social Assessments Regarding Developments Proposed to Take Place on, or Which are Likely to Impact on, Sacred Sites and on Lands and*

Waters Traditionally Occupied or Used by Indigenous and Local Communities (Akwe: Kon Voluntary Guidelines).

(ii) World Intellectual Property Organization

In 2000, the World Intellectual Property Organization (WIPO) set up the Inter-Governmental Committee on Genetic Resources, Traditional Knowledge, and Folklore (IGC) to explore the relationship of the intellectual property system to the intangible heritage and associated resources and expressions of Indigenous peoples and local communities. In 2009 they began negotiating a potentially internationally binding treaty targeted to be completed by 2012.

CONVENTION ON BIOLOGICAL DIVERSITY: INTERNATIONAL REGIME ON ACCESS AND BENEFIT SHARING

The CBD International Regime on ABS is looking at issues related to the international trade in genetic resources. In the past, the developed countries of the North have often been accused of biopiracy, or of taking genetic resources freely from their source locations in developing countries without permission and/or compensation. Ethnobiologists have been accused by Indigenous peoples and activists of directly and indirectly facilitating this kind of unfair misappropriation (Posey and Dutfield 1996). Biotechnology corporations have developed natural products based on ethnobotanical leads and the use of genetic resources derived from Indigenous peoples without permission or compensation (Kloppenborg 1991). The issue of what precisely constitutes biopiracy is complex (for a recent in-depth treatment, see Robinson 2010).

In relation to Indigenous peoples, the ABS Regime can be broken into two parts—issues related to *access* to traditional knowledge and associated resources, and issues related to *benefit sharing* once traditional knowledge or genetic resources have been obtained. Article 15 of the CBD asserts that the states are sovereign over their natural resources, such that any other state that wishes to access them must first obtain permission, or *prior informed consent* from the sovereign. State sovereignty over genetic resources was a dramatic reversal of an earlier principle of international law, that is, that genetic resources formed a part of the common heritage of humankind. Under Article 15, sharing is based on the consent of both parties to the terms of the sharing agreement, or *mutually agreed terms*. Both PIC and MAT ensure that an agreement must be made before genetic resources can be obtained and used, and thus set the conditions for benefit sharing.

Article 15 also recognizes rights to ABS for Indigenous and local communities, but is not specific as to how these rights will be implemented. The ABS Regime addresses this in more detail. While the ABS Regime had not been finalized at the time of writing, several observations can be made relating to the practice of ethnobiology. As noted, the CBD stipulates that states are sovereign over genetic resources. This is disputed by many Indigenous peoples, who believe the *Declaration on the Rights of Indigenous Peoples* and other international law support a claim to their own sovereign rights to genetic resources.

The ABS Regime does contemplate Indigenous and local community rights over genetic resources, but these rights are subject to national legislation. The ABS Regime, therefore, will most likely only give guidance in this regard, and leave it to the states to decide how to take that guidance. The scope may be limited only to genetic resources occurring directly on Indigenous territories (i.e., not yet collected), or include genetic resources held

in museums, collections, seed banks, or gene banks. Even if Indigenous peoples fail to gain recognition of their sovereign rights, or if the scope is limited, they will likely increasingly have recognized rights to control access to some subset of national genetic resources in most cases.

The scope of rights for traditional knowledge related to the conservation and sustainable use of biodiversity is also still under debate. Indigenous peoples have consistently argued that in their cosmivision, traditional knowledge and genetic resources cannot be separated, and have defended language that always refers to “rights to traditional knowledge and associated genetic resources” combined. Many states have tried to limit their obligations only to traditional knowledge, with the majority of the control over access to genetic resources remaining vested in the state.

Despite Indigenous cosmivision, it is common for traditional knowledge and genetic resources to be considered separately. There are four common permutations of how traditional knowledge and genetic resources are encountered, each raising different sets of issues: (i) undisclosed traditional knowledge held within a group, with genetic resources acquired outside legal territories; (ii) disclosed traditional knowledge found away from Indigenous territories (e.g., in books, databases, the minds of neighbors) with genetic resources acquired on the territories; (iii) both disclosed traditional knowledge and associated genetic resources acquired away from Indigenous territories; and (iv) disclosed traditional knowledge found away from Indigenous territories, and genetic resources acquired on them.

Each scenario presents difficult ethical and legal issues. For example, how does one identify rights holders to traditional knowledge that is widely circulated? Are there rights to control access and/or derive benefits? In the Western system, once knowledge has been disclosed publically, it begins a journey towards the public domain, in which others may have free access to the knowledge without any obligations to the original holders. This may not be consistent with the belief of the knowledge holders themselves, who often hold that there are spiritual values and social and spiritual obligations that are inextricably linked to the use of the knowledge, as well as harms that may result from misuse (Tulalip Tribes 2003).

There is also the issue of “embodied traditional knowledge”. Economists and intellectual property lawyers have referred to the knowledge embodied in technology—the structure of technological innovations contains information about the knowledge that went into its construction. National and international technology law protects innovators against reverse engineering or the unauthorized extraction of such knowledge through inference from design. Indigenous peoples, for example through countless generations of selection and breeding, have also embodied their traditional knowledge in the breeding of plants and animals and the creation of biocultural landscapes. To the extent that their labor has shaped the pool of genetic resources, questions arise about rights to control access and/or share in the benefits of their use. The current ABS Regime acknowledges such embodied traditional knowledge, but only provides a recommendation that benefits should be shared.

The two strongest outcomes from the ABS Regime are likely to be related to the issue of PIC and the recognition of the importance of customary law in determining conditions of both access and benefit sharing. In Article 15 of the CBD, PIC refers to a government-to-government relationship in which one government must obtain legal consent from a delegated authority of another state before an action is started. Governments create specific offices with decision-making authority to which those wishing to access genetic resources apply, and the agencies are empowered to give an unambiguous reply to accept or deny

access, and provide the terms of access if it is given. The ABS Regime will likely recognize that Indigenous and local communities also have the right to PIC for currently undisclosed traditional knowledge. The scope of rights to disclosed traditional knowledge and associated genetic resources is still under negotiation, but some states are expected to adopt domestic legislation that requires potential users of traditional knowledge and associated genetic resources to obtain consent before access and use, regardless of whether the uses are commercial or non-commercial.

Indigenous peoples are also promoting the recognition of customary law by the ABS Regime. This is important because it is the basis on which Indigenous peoples value and make decisions on access and benefit sharing related directly to their customs, and beliefs about proper and improper uses of traditional knowledge and genetic resources, including the moral, spiritual, and physical consequences of violating those beliefs. Many Indigenous peoples consider themselves stewards or guardians of the land and other living beings, based on a model of proprietorship rather than property owners (Carpenter et al. 2009; Tsosie 2000). They believe it is both a matter of ethics and political self-determination to directly recognize their right to set the terms and conditions of the use of their knowledge and genetic resources, and to have their beliefs respected outside of their lands.

The above is difficult to achieve in practice, as even sovereigns cannot directly require respect of their beliefs or laws from other sovereigns. But it is in the nature of treaties that sovereigns cross-recognize one another's laws on the basis of mutual benefit. Such mutual recognition of national laws, known as comity, is a common outcome of treaties. Indigenous peoples are asked to recognize the national laws related to non-Indigenous property, and they believe it is part of the right to self-determination, as recognized in the *United Nations Declaration on the Rights of Indigenous Peoples*, to have their legal traditions respected. The scope of this principle in the ABS Regime is still unclear, but it is recognized that, at a minimum, Indigenous peoples can embody their beliefs in setting the terms of access and use of their traditional knowledge and genetic resources according to MAT, which are consistent with their traditions.

In summary, the ABS Regime is likely to affect ethnobiological research by increasingly recognizing the legal, political, and human rights of Indigenous peoples to varying extents to control access to and the use of their traditional knowledge and associated genetic resources.

WIPO INTERGOVERNMENTAL COMMITTEE ON GENETIC RESOURCES, TRADITIONAL KNOWLEDGE AND FOLKLORE (IGC)

Many of the issues raised by the CBD are also raised in treaty negotiations at WIPO. Indigenous representatives have objected to the negotiations because of their perceptions of the nature of IPR. Their position is that the rights to Indigenous intangible cultural heritage arise from their spiritual and political traditions, which are protected through human rights rather than property rights. As in the discussion of genetic resources, they believe that the existing intellectual property system cannot be sufficient to protect their rights because the system is fundamentally based on commercialization, commodification, and alienation of rights of ownership or guardianship (Sunder 2007). Other Indigenous scholars and representatives are more supportive of the potential for *sui generis* legal principles to protect intangible knowledge, genetic resources and tangible expressions, using these negotiations as an opportunity to correct "flaws" in the current system (Carpenter et al. 2009).

Both sides agree that there are significant barriers to protection in the current IPR system. The general theory behind intellectual property law is that people require incentives to produce innovations. Sovereigns, therefore, grant monopolies for limited periods of time to innovators, allowing the latter to control and prosper from their innovations. The developers of intellectual property theory proposed limited durations for protection because it was obvious that if IPR did not expire, knowledge would quickly grow into an impassable thicket of exclusive property. The concept of the public domain was created as a conceptual space where intangible creations would become free for anyone to use anywhere without restriction as part of the common heritage of humankind.

In many intellectual property systems around the world, the monopolies run for about 20 years for patents, and “life plus 70” for copyrights (from the time of production to the end of the creator’s life, plus 70 years). There are three important exceptions to this rule: trade marks, trade secrets, and geographical indications, which have indefinite terms of protection. Trade marks, like Coca-Cola™, are visual symbols that are protected as long as they are used. Trade secrets, like the formula for Coca-Cola™, are protected as long as they are kept secret. Geographical indications are appellations (geographically based names) that are permanently tied to products from particular groups or regions. If a product advertizes itself as a Bordeaux wine, it must be produced in the Bordeaux region in France.

The intellectual property system makes certain exceptions to protection. Copyrighted works only protect the exact expressions contained in the works, but do not protect the information contained in the expression. Users of copyrighted works can, therefore, extract the information and use it immediately, without having to wait for the copyright to expire into the public domain. In many countries, fair use laws allow users to extract small amounts of expressions in texts without have to ask for permission or pay a fee to a copyright holder. Both of these exceptions are tied to the concept of freedom of expression, a strong democratic ideal and fundamental human right that keeps people free from coercion and oppression. The laws also generally make exceptions for non-commercial, educational, and reporting uses.

These existing intellectual property law principles can be contrasted with the circulation and regulation of knowledge, genetic resources, and traditional cultural expressions within Indigenous communities. Traditional societies can mostly be characterized as having strong spiritual traditions, which permeate all aspects of their societies (Posey 1999). They do not generally view their knowledge as “data” or “information”, but often as something that has its origin and continuing connections to a spiritual domain. Even reference to the “intangible” can misrepresent traditional concepts of knowledge, as many Indigenous peoples believe knowledge is material and tangible and has existence in the spirit world. There is, of course, no single description of how Indigenous peoples view and use their knowledge, and there is a wide spectrum of concepts ranging from the relatively secular and practical to the highly sacred and secret (Rose 1995).

The idea of the public domain is absent or much diminished in traditional societies (Gibson 2007; Sunder 2007; Tauli-Corpuz 2005; Tualip Tribes 2003). Consider the classic example of a family song where it is sung in public. Although the audience may hear the song, it is also aware that the song is entrusted to the family, which has the sole proprietary right to sing it. The use of the song is socially regulated by traditional sanctions, norms and institutions, or customary law. Under many cultural rules, controls on the use of family songs are perpetual. Similarly, Indigenous peoples have secret, ritual, or ceremonial practices, which under their traditions are not to be shared or used outside their appropriate contexts.

Still, much knowledge is not guarded in this way, and may be widely circulated. Agricultural knowledge and resources such as seeds and tubers are often shared widely

within and between communities (Brush 2004). Even in these cases, such sharing is often accompanied by beliefs about their appropriate uses, and obligations to respect spiritual and social norms, such as showing reciprocity for shared resources (Matsumura 2006; but see Brush 2005). Previously shared knowledge raises factual, normative, and strategic issues. A description of a historical pattern is factual, but that is not, in itself, sufficient to make it normative. To do so would be to commit the naturalistic fallacy of claiming that whatever naturally occurs is justified simply by its natural occurrence. Even if agricultural knowledge has been widely shared, it was historically shared among rural peoples with similar worldviews, which is very different from today's densely populated, digitally connected, and technologically advanced world where agricultural knowledge takes on many dimensions that it did not have in the past.

The above leads to strategic considerations of the governance of traditional knowledge. Different types of knowledge may have different governability. Knowledge about growing potatoes, for example, can largely be applied only to potatoes. Growing a potato is a demanding task, and occurs in a specific place. If one shares knowledge about growing potatoes with others, the main way they can use it is to grow potatoes themselves on their own lands. In primarily subsistence economies, there will likely not be high competition for potato markets, so sharing the knowledge is an example of non-rivalry where another's use of knowledge or resources does not interfere with one's own. This is asserted with a caveat. Rivalry and non-rivalry related to traditional knowledge are applied with the significant assumption that it only involves the information content of the knowledge. Indigenous peoples who believe that there are spiritual dimensions of knowledge, that misuse has cosmic and physical impacts, or that knowledge is expressed through sacred breath would evaluate rivalry and non-rivalry using different criteria.

Traditional agricultural knowledge can be contrasted with knowledge of the uses of wild living resources. Wild species will generally occur at much lower abundances and have greater variability. Sharing knowledge about a relatively scarce resource that one has little control over can lead to rival uses, where others do interfere with one's own access because of competition for the same resource. The issue of governability of traditional knowledge and associated resources, linking life-history characteristics of exploited species and social-ecological variables, is in its infancy, but is important in understanding strategic issues in making decisions related to knowledge and resources, particularly in a globalized world.

The IGC is not expected to finish its work until 2012 at the earliest, and not all United Nations treaty negotiations are completed. But there is wide recognition that the current IPR laws are not protecting Indigenous peoples from the exploitation of their intangible knowledge, or from the improper granting of IPR to products derived from their resources without permission. One of the current principles under discussion is to provide an indefinite term of protection to traditional cultural expressions (e.g., art, dance, music, symbols, patterns) for an indefinite period in a way similar to trade marks. The protections would last as long as the holders of the traditions persist as recognizable peoples.

CONTEMPORARY ISSUES FOR ETHNOBIOLOGISTS

The considerations outlined above highlight just a few of the wicked problems posed by the intellectual property system, access and benefit sharing agreements, and the collection, dissemination, and use of traditional knowledge. Governments, Indigenous peoples, and

academics are grappling with many interrelated ethical and legal issues. The United Nations is not alone in developing laws; a number of governments are developing constitutional provisions or statutes, and some regional organizations (e.g., the Andean Pact among South American governments) have elaborated (or are elaborating) their own regimes. Ethnobiologists will face increasing regulation of access and use of traditional knowledge in the near future.

Academic and scientific commitments are deeply linked to beliefs in freedom of expression, the common heritage of human kind, and the value of the public domain. Many ethnobiologists work within the evolutionary tradition, which tells a specific materialistic story about the origin of humankind, its evolution and dispersal across the globe, and about the diffusion and mixing of knowledge, resources, and cultures. The scientific narratives are well corroborated, and the principles deserve deep respect. However, it must also be recognized that these narratives can conflict with narratives, beliefs, and principles that are held just as deeply by Indigenous peoples. The negotiations are occurring at a site of high contestation between worldviews.

Characterizing Indigenous worldviews in any realistic way is not possible here, but a common gross generalization is that Indigenous peoples have a collective identity based on creation stories that tell them where they came from, which ties them to the land. They often tell of a sacred journey, of creation or emergence in place, or of cosmological origin. Although there are many accounts that refer to traditional knowledge as an adaptive system developed by trial and error over millennia, this is not the account given by many tradition holders (Posey 1999). Although they recognize the role and value of experimentation and innovation, they commonly believe this is based on a deeper reality where knowledge comes as a gift of the Ancestors, Spirits, or Creator, and may come from direct communication with beings in a cosmic dimension, in dreams, or in direct conversation with plants and animals. The spiritual nature of this knowledge creates correlative rights and responsibilities, and sets appropriate uses (Solomon 2004). They are correlative in the sense that it makes no sense for many Indigenous peoples to talk about rights without also respecting obligations. This is the basis for the claim that there generally is no exact equivalent of the public domain in Indigenous cultures, because knowledge and resources are never unregulated, and always associated with customary laws or community protocols.

The UNDRIP, the CBD and the IGC all represent a movement to recognize Indigenous rights and a new pluralism to respect other ways of thinking and being. These efforts are far from ideal. The dispute over concepts is high. The legal non-Indigenous worldview has become entrenched from hundreds of international agreements over 100 years, with long discussions required to come to common understandings of legal terms of 195 United Nations-recognized states.

If a plant processing method has been held within a family “since time immemorial”, is there any justification under intellectual property law or scientific ethics that could justify its being appropriated into the public domain, or freely used on the justification of freedom of expression? Can an exemption be made on the basis of non-commercial research, if there is a high likelihood that once disclosed in a publication, the knowledge would be unfairly exploited? And what should be done with knowledge that is already in circulation, recorded in texts, or housed in databases, that the legal system and most publics consider to already be in the public domain? Did the transfers of knowledge occur based on a full understanding by all parties of the consequences of sharing, or on mutually agreed terms? Was the sharing based on an agreement involving entire communities who made a collective decision to share their knowledge held in common?

One common reason for making traditional knowledge available is that it can defeat improperly issued patents. For a patent to be valid, it has to be a true invention. If it is based on something previously known that is part of the public domain (“prior art”), it cannot be patented. Some have used this reasoning to advocate the widespread development of databases of traditional knowledge in the public domain (Alexander et al. 2004; Hardison 2005). But defeating patents is only one issue with which Indigenous peoples are concerned—even non-commercial research may pose ethical and spiritual issues. Patents concern 20-year monopolies, and defeating them only stops the monopoly, not non-monopolistic commercial or non-commercial uses. In the Pacific Northwest, for example, tribes are much less concerned about biopiracy from pharmaceutical companies than about non-tribal harvesters who harvest scarce cultural resources and leave the traditional practitioners with little or nothing to perform ceremonies or rituals or for subsistence.

Indigenous peoples have expressed their willingness to share some of their knowledge for good causes, and even with the politicization of these debates, many still work and will continue to work with academic researchers. Indigenous peoples generally are not against all sharing, and there are many reciprocal benefits from this kind of research. They have clearly expressed the desire to reserve their most sacred traditions to themselves, to require their free, prior, and informed consent, to have their knowledge protected and to have their customary laws and community protocols respected. Giving consent will require that all parties understand the terms being used, have a clear understanding of all reasonably known outcomes and consequences, identify a process through which an authoritative decision can be made in the face of conflict, and agree on a method of fair and culturally acceptable conflict resolution (Bell and Kahane 2005; Hardison 2006; United Nations Economic and Social Council 2005).

Sorting these issues out and respecting Indigenous expectations is not easy. Ethnobiologists need to pay close attention to the terms of the dialogues, try not to make assumptions, and ensure that the rights and aspirations of the holders of the knowledge are respected. The potential for misunderstanding can be high. For example, several meanings of “protect” have been used in the United Nations system, national laws and stakeholder discussions. Protect may mean: (i) protection against extinction, in this case the knowledge should be recorded and distributed as widely as possible; (ii) protection as part of the global commons or common heritage of human kind, a position that proposes recording and wide dissemination, and supports the idea of traditional knowledge being in the public domain, or temporarily regulated by licenses that have few restrictions on use; (iii) protection against any use by outsiders, a position that is commonly applied to secret and sacred knowledge; (vi) protection against use contrary to customary law and spiritual values; (iv) protection against some or all commercial uses; or (vii) protection of benefit sharing, that is, ensuring that if traditional knowledge is used, the holders of knowledge can receive and determine the type of benefits they receive, which may be non-monetary benefits. Capacity-building and information-sharing, for example, are common desired outcomes for research partnerships.

Traditional knowledge and resources may not be treated in a single way. Communities will make their own classification and decisions about different types. Indigenous peoples may elect to put some types of knowledge in the public domain or create a traditional knowledge commons license—a kind of contract that can allow for wide use while reserving the right to control some uses, such as commercial use. For other types, such as secret and sacred knowledge, strict protection may be sought.

In many cases, PIC will be a difficult standard to meet, at least until Indigenous peoples create institutions to address these new situations. Individualism is favored in legal systems,

in part because it is relatively easy to define an authoritative agent with a clear right to make decisions—the individual, or the corporation figured as an individual. As discussed previously, many groups do not have a social structure that easily fits onto the classic “notional community” (a theoretical or imagined community). There are significant questions about how to sort out disputes within and between communities. Identifying a process to get a collective authoritative answer can be difficult.

Anthropologists have a long history of study on the issue of knowledge diffusion (Brown 2003.), and understand that there are likely to be many cases of confusion, power struggles, and contested claims over the identification of rights holders (Brown 1998; Nicholas and Bannister 2004). Some Indigenous culture groups, like the Athabaskans and Coast Salish, may share knowledge and resources in common over a wide area, and dispute decisions about sharing them.

Indigenous peoples and researchers alike will have to become more knowledgeable about the IPR system, the human rights system, and emerging laws and principles. Indigenous peoples do not usually have a history with activities such as publishing, recording, or patenting, which would put them in contact with the IPR system. Even researchers can be naïve about IPR, for example the distinction between fact and expression, the typical passage from protection to the public domain in the current intellectual property system, and the inability to ensure protection (as Indigenous peoples understand it) once knowledge has been published. For example, under the Bayh-Dole Act (University and Small Business Patent Procedures Act of 1980) in the United States, the federal government allows universities to apply for IPR for federal government-funded research. Most universities today aggressively pursue this right, and even put conditions into faculty contracts that force them to pursue, or allow the university to pursue, patents on their research. Often the university, not the researcher, holds the patents. Dissertation and other publishing requirements of universities, as well as freedom of information laws, may not be able to ensure that all personal agreements between researchers and Indigenous communities can be honored. The commitments that an individual can uphold are often limited by the policies of the institutions to which they have employment obligations.

As applied scientists, ethnobiologists straddle the worlds of scientific understanding and social justice, according the priorities and lenses of science, and seeking equity for the peoples with whom they work. To sit astride this divide requires great skill, sensitivity and diplomacy. Indigenous worldviews and political struggles may use narratives that do not always fit comfortably with scientific models and evidence. Even where there may be a general fit, there are conflicts in the details. There are two broad threats in these conflicts. The first concerns the potential contribution of scientists to the erosion of the underlying belief systems that maintain traditions and beliefs that underlie desired ends, such as conservation practices, sustainable harvest, and the maintenance of biocultural diversity. The second is that when the scientific evidence conflicts with Indigenous narratives, scientists can have adverse impacts on Indigenous political struggles to achieve recognition of their human rights and rights to their traditional lands and waters.

When faced with these dilemmas, ethnobiologists should keep in mind the aphorism, *primum non nocere* (Latin: “first, do no harm”—origin uncertain but often ascribed to Hippocrates). In part, this requires developing a working understanding of the larger ethical, legal, and political picture in which research is embedded. It also involves gaining a level of cultural competency at the local level, understanding community research protocols and governance structures, enabling meaningful community participation, and being mindful not to impose external assumptions about what constitutes “help” on Indigenous and local peoples who will speak for themselves if the rest of us listen.

REFERENCES

- ALEXANDER M, CHAMUNDEESWARI K, KAMBU A, MULLER MR, TOBIN B. The role of registers and databases in the protection of traditional knowledge. Yokohama: United Nations University Institute for Advanced Studies (UNU/IAS); 2004.
- AMERICAN ANTHROPOLOGICAL ASSOCIATION. Code of ethics of the American Anthropological Association; 1998. Available at <http://www.aaanet.org/committees/ethics/ethcode.htm>.
- BANNISTER K, SOLOMON M. Part I: appropriation of traditional knowledge: ethics in the case of ethnobiology. In: YOUNG JO, BRUNK, CG, editors. *The ethics of cultural appropriation*. Massachusetts: Wiley-Blackwell; 2009a. p 140–172.
- BANNISTER K, SOLOMON M. Indigenous knowledges. In: IRIYE A, SAUNIER P-Y, editors. *The Palgrave dictionary of transnational history*. Basingstoke: Palgrave Macmillan; 2009b. p 523–526.
- BELL C, KAHANE DJ, editors. *Intercultural dispute resolution in Aboriginal contexts*. Seattle: University of Washington Press; 2005.
- BLUNT P, WARREN DM, editors. *Indigenous organizations and development*. London: Intermediate Technology Publications; 1996.
- BROWN M. Can culture be copyrighted? *Curr Anthropol* 1998; 39(2):193–192.
- BROWN M. *Who owns native culture?* Cambridge (MA): Harvard University Press; 2003.
- BRUSH SB. Reconsidering the green revolution: diversity and stability in cradle areas of crop domestication. *Hum Ecol* 1992;20:145–168.
- BRUSH SB. *Farmers' bounty: the survival of crop diversity in the modern world*. New Haven (CT): Yale University Press; 2004.
- BRUSH SB. *Farmers' rights and protection of traditional agricultural knowledge*. CAPRI working paper 36. Washington (DC): CGIAR Systemwide Program on Collective Action and Property Rights (CAPRI); 2005.
- CIHR (CANADIAN INSTITUTES OF HEALTH RESEARCH). *CIHR guidelines for health research involving Aboriginal people*; 2007. Available at <http://www.cihr-irsc.gc.ca/e/29134.html>.
- CIHR (CANADIAN INSTITUTES OF HEALTH RESEARCH), Natural Sciences and Engineering Research Council of Canada, Social Sciences and Humanities Research Council of Canada. *Tri-Council policy statement: ethical conduct for research involving humans*; 1998 (with 2000, 2002, and 2005 amendments). Available at <http://pre.ethics.gc.ca/eng/policy-politique/tcps-eptc/>.
- CARPENTER KA, KATYAL SK, RILEY AR. In defense of property. *Yale Law J* 2009;118:1022–1046.
- CARSON R. *Silent spring*. Boston (MA): Houghton Mifflin; 1962.
- CHAMBERS R, editor. *Rural development: whose knowledge counts?* *IDS Bull* 1979; 10(2), 27–49.
- CHAMBERS R, PACEY A, THRUPP LA, editors. *Farmer first: farmer innovation and agricultural research*. London: Intermediate Technology Publications; 1989.
- CLAWSON DL, HOY DR. Nealtican: a Mexican community that rejected the green revolution. *Amer J Econ Sociol* 1979; 38:371–387.
- CONWAY GR, BARBIER EB. *After the green revolution: sustainable agriculture and development*. London: Earthscan Publications; 1990.
- DOWNIE RS. Ethics and morality. In: HONDERICH T, editor. *The Oxford guide to philosophy*. Oxford: Oxford University Press; 2005. p 271.
- ESCOBAR A. Anthropology and the development encounter. *Am Ethnol* 1991;18(4):658–682.
- FARHATA R. Neotribal entrepreneurialism and the commodification of biodiversity: WIPO's displacement of development for private property rights. *Rev Int Polit Econ* 2008; 15(2):206–233.
- GENERAL ASSEMBLY OF THE UNITED NATIONS. *United Nations declaration on the rights of indigenous peoples (UNDRIP)*. New York: United Nations; 2007. Available at <http://www.un.org/esa/socdev/unpfii/en/declaration.html>.
- GIBSON J. Audiences in tradition: traditional knowledge and the public domain. In: WAELEDE C, MACQUEEN H, editors. *Intellectual property: the many faces of the public domain*. Cheltenham: Edward Elgar; 2007. p 174–188.
- HARDISON PD. *The report on traditional knowledge registers (TKRs) and related traditional knowledge databases (TKDBs)*. UNEP/CBD/WG8J/4/INF/9. Montréal: Secretariat of the Convention on Biological Diversity (SCBD); 2005.
- HARDISON PD. *Indigenous peoples and the Commons*. On the Commons, December 2006. Available at <http://onthecommons.org/indigenous-peoples-and-commons>.
- HENRIKSEN JB. *Key principles in implementing ILO Convention No. 169*. Paris: Programme to Promote ILO Convention No. 169 (Pro-169); 2008.
- HILL JN. The Committee on Ethics: past, present, and future. In: CASSELL J, JACOBS S-E, editors. *Handbook on ethical issues in anthropology*. American Anthropological Association, special publication 23; 1998. Available at <http://www.aaanet.org/committees/ethics/toc.htm>.
- INTERNATIONAL LABOUR ORGANIZATION. *Indigenous and Tribal Peoples Convention 169*. Paris: International Labour Organization; 1989. Available at <http://www.ilo.org/ilolex/cgi-lex/convde.pl?C169>.
- INTERNATIONAL LABOUR ORGANIZATION. *Indigenous and Tribal Peoples in Practice*. Paris: International Labour Organization; 2003.
- INTERNATIONAL SOCIETY OF ETHNOBIOLOGY. *Declaration of Belém*; 1988. Available at http://www.ethnobiology.net/global_coalition/declaration.php.
- INTERNATIONAL SOCIETY OF ETHNOBIOLOGY. *International Society of Ethnobiology code of ethics*

- (with 2008 additions); 2006. Available at www.ethnobiology.net/ethics.php.
- INTERNATIONAL SOCIETY OF ETHNOBIOLOGY. History of the International Society of Ethnobiology. Available at http://www.ethnobiology.net/about_us/history.php.
- JOHANNES RE. Traditional marine conservation methods in Oceania and their demise. *Annu Rev Ecol Syst* 1978; 9:349–364.
- JONES J. Bad blood: the Tuskegee syphilis experiment: a tragedy of race and medicine. New York: The Free Press; 1981.
- KLOPPENBURG JR JR. No hunting! Biodiversity, indigenous rights, and scientific poaching. *Cult Surv Quart* 1991; 15(3):14–17.
- LI TM. Indigeneity, capitalism, and the management of dispossession. *Curr Anthropol* 2010;51(3):385–414.
- LIDDELL HG, SCOTT R. A Greek–English lexicon. Oxford: Clarendon Press; 1940. Perseus Digital Library Project available at <http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.04.0057%3Aentry%3D%2346783&redirect=true>. Accessed 2010 Apr 4.
- MATSUMURA K. Moral economy as emotional interaction: food sharing and reciprocity in Highland Ethiopia. *Afr Stud Quart* 2006;9(1&2):9–22.
- MAURO F, HARDISON PD. Traditional knowledge of indigenous and local communities: international debate and policy initiatives. *Ecol Appl* 2000; 10(5):1263–1269.
- MITSCHELICH A, MIELKE F, editors. The Nuremberg code (1947). In: *Doctors of infamy: the story of the Nazi medical crimes*. New York: Schuman; 1949. p xxiii–xxv. Available at <http://www.hhs.gov/ohrp/references/nurcode.htm>.
- NATIONAL ACADEMY OF SCIENCES. On being a scientist: responsible research conduct in research. Washington (DC): National Academy Press; 1995.
- NATIONAL COMMISSION. Belmont report: ethical principles and guidelines for the protection of human subjects of research. National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, Washington (DC); 1979. Available at <http://www.hhs.gov/ohrp/humansubjects/guidance/belmont.htm>.
- NICHOLAS GP, BANNISTER KP. Copyrighting the past? Emerging intellectual property rights issues in archaeology. *Curr Anthropol* 2004;45(3):327–350.
- PELUSO NL. Rich forest, poor people: resource control and resistance in Java. Berkeley: University of California Press; 1992.
- POSEY DA, editor. Cultural and spiritual values of biodiversity: a complementary contribution to the global biodiversity assessment. London: Intermediate Technology Publications (ITP); 1999.
- POSEY DA. Commodification of the sacred through intellectual property rights. *J Ethnopharmacol* 2002;83:3–12.
- POSEY DA, DUTFIELD G. Beyond intellectual property rights: toward traditional resource rights. Ottawa: International Development Research Centre (IDRC); 1996.
- ROBINSON DF. Confronting biopiracy: challenges, cases and international debates. London: Earthscan; 2010.
- ROSE DB. The public, the private and the secret across cultural difference. In: FINLAYSON JD, JACKSON-NAKANO A, editors. *Heritage and native title: anthropological and legal perspectives*. Proceedings of a workshop conducted by the Australian Anthropological Society and the Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra, 14–15 February 1996. Canberra: Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS); 1995. pp. 113–128.
- SECRETARIAT OF THE UNITED NATIONS CONVENTION ON BIOLOGICAL DIVERSITY. Bonn guidelines on access to genetic resources and fair and equitable sharing of the benefits arising out of their utilization. Montréal: Secretariat of the United Nations Convention on Biological Diversity (SCBD); 2002. Available at <http://www.cbd.int/abs/bonn.shtml>.
- SECRETARIAT OF THE UNITED NATIONS CONVENTION ON BIOLOGICAL DIVERSITY. Report of the Sixth Meeting of the Ad Hoc Open-Ended Inter-Sessional Working Group on article 8(j) and related provisions of the Convention on Biological Diversity. UNEP/CBD/COP/10/2. Montréal: Secretariat of the United Nations Convention on Biological Diversity (SCBD); 2009. Available at <http://www.cbd.int/doc/meetings/cop/cop-10/official/cop-10-02-en.pdf>.
- SHIVA V. The violence of the green revolution: third world agriculture, ecology and politics. Penang, Malaysia/London: Third World Network/Zed Books; 1989.
- SKEAT WW. An etymological dictionary of the English language. Oxford: Clarendon Press; 1963.
- SOLOMON M. Intellectual property rights and indigenous peoples' rights and responsibilities. In: RILEY A, editor. *Indigenous intellectual property rights: legal obstacles and innovative solutions*. Walnut Creek (CA): AltaMira Press; 2004. p 221–250.
- SUNDER M. The invention of traditional knowledge. *Law Contemp Probl* 2007;70(2):97–124.
- SWIDERSKA K. Protecting traditional knowledge: a holistic approach based on customary laws and bio-cultural heritage. In: NINAN KN, editor. *Conserving and valuing ecosystem services and biodiversity*. London: Earthscan; 2008.
- TAULI-CORPUZ V. Biodiversity, traditional knowledge and rights of indigenous peoples. Permanent Forum on Indigenous Issues: Workshop on Traditional Knowledge, the United Nations and Indigenous People, 21–23 September 2005, Panama City, Panama PFII/2005/WS.TK/5. New York: United Nations Department of Economic and Social Affairs – Division for Social Policy and Development – Secretariat of the Permanent Forum on Indigenous Issues; 2005. p. 33. http://www.un.org/esa/socdev/unpfii/documents/TK_Paper_Vicky_English.pdf.
- TSOSIE R. Sacred obligations: intercultural justice and the discourse of treaty rights. *UCLA Law Rev* 2000; 47(6):1615–1672.
- TULALIP TRIBES. Statement by the Tulalip tribes of Washington on folklore, indigenous knowledge, and the

- public domain, 9 July 2003. Geneva: World Intellectual Property Organization; 2003.
- TUSKEGEE UNIVERSITY. Information about the USPHS syphilis study “Tuskegee study of untreated syphilis in the negro male”; 2010. Available at <http://www.tuskegee.edu/Global/story.asp?S=6377076>.
- UNITED NATIONS ECONOMIC AND SOCIAL COUNCIL. Report of the International workshop on methodologies regarding free, prior and informed consent and indigenous peoples (New York, 17–19 January 2005). EC.1920053. New York: United Nations Economic and Social Council; 2005. Available at <http://www.un.org/esa/socdev/unpfii/en/workshopFPIC.html>.
- UNITED NATIONS ENVIRONMENT PROGRAM. United Nations convention on biological diversity (CBD). Nairobi: United Nations Environment Program; 1993. Available at <http://www.cbd.int/>.
- UNITED NATIONS PERMANENT FORUM ON INDIGENOUS ISSUES (UNPFII). State of the world’s indigenous peoples. New York: Secretariat of the Permanent Forum on Indigenous Issues; 2010.
- UNITED NATIONS PERMANENT FORUM ON INDIGENOUS ISSUES WEBSITE. <http://www.un.org/esa/socdev/unpfii/index.html>.
- WILLIAMS B. Ethics and the limits of philosophy. Massachusetts: Harvard University Press; 1985.

Chapter 4

From Researcher to Partner: Ethical Challenges and Issues Facing the Ethnobiological Researcher

MICHAEL P. GILMORE

New Century College, George Mason University, Fairfax, VA

W. HARDY ESHBAUGH

Department of Botany, Miami University, Oxford, OH

INTRODUCTION	52
KEY QUESTIONS FOR ETHNOBIOLOGISTS	52
1. HAVE YOU RECEIVED PROPER PERMISSION TO CONDUCT YOUR RESEARCH?	52
2. HAVE YOU THOUGHT ABOUT AND INCORPORATED LOCAL NEEDS, CHALLENGES, AND PRIORITIES INTO THE RESEARCH PROJECT?	55
3. WHO IS BENEFITING FROM THE RESEARCH AND HOW ARE COLLABORATING COMMUNITIES AND INDIVIDUALS BEING COMPENSATED?	56
4. HOW WILL THE RESULTS OF THE RESEARCH PROJECT BE SHARED AND USED?	57
5. ARE THE INTERESTS OF COLLABORATING COMMUNITIES AND INDIVIDUALS BEING ACKNOWLEDGED AND PROTECTED WHEN DISSEMINATING RESEARCH RESULTS?	58
CASE STUDY 4.1	59
CONCLUSION	61
ACKNOWLEDGMENTS	61
REFERENCES	61

INTRODUCTION

Many subdisciplines of ethnobiology require the researcher to work directly with both Indigenous and local communities. Consequently, not only are ethnobiologists at the interface of different disciplines, they are also at the interface of different cultural, social, political, and economic realities and worlds. In addition, ethnobiological researchers often work with marginalized communities experiencing enormous sociocultural and environmental pressures and changes, further challenging the researcher (Alexiades 1996; Alexiades and Laird 2002; Cunningham 1996). These conditions create a multidimensional, complex, and ever-changing ethical landscape for the ethnobiological researcher to navigate. Additionally, the relationships between researchers and communities more often than not are played out in a context of asymmetry in power, privilege, and intent, further complicating the host of ethical challenges and concerns confronting the ethnobiologist.

In order to properly engage with these ethical challenges and concerns, we propose and discuss five critical questions that every ethnobiologist should ask prior to beginning a research project.

1. Have you received proper permission to conduct your research?
2. Have you thought about and incorporated local needs, challenges, and priorities into the research project?
3. Who is benefiting from the research and how are collaborating communities and individuals being compensated?
4. How will the results of the research project be shared and used?
5. Are the interests of collaborating communities and individuals being acknowledged and protected when disseminating research results?

These questions and their answers address many of the major ethical challenges and issues facing the ethnobiological researcher, including prior informed consent (PIC), research permits, compensation, equitable benefit sharing, and the publication of research results, among others.

KEY QUESTIONS FOR ETHNOBIOLOGISTS

1. Have You Received Proper Permission to Conduct Your Research?

Prior to undertaking any ethnobiological research activities, researchers must seek the proper permits and permission to proceed from the appropriate stakeholders. The stakeholders involved in ethnobiological research projects commonly cross cultural, economic, and political boundaries and include the researcher, the sponsoring organization or institution, the government where research will be conducted, the participating Indigenous or local community, and individual research participants. Reasons for obtaining the proper permits and permission are many, but on the most basic level, researchers must never forget that they are guests of host countries and communities and therefore have ethical responsibilities to act in accordance with national and local rules and regulations (Boom 1990). Additionally, Indigenous peoples' groups have articulated through declarations and statements their desire for more equitable research partnerships and the need for researchers to seek and negotiate access to their knowledge, resources, and territories (Dutfield 2002). As stated

in the International Society of Ethnobiology *Code of Ethics* (ISE 2006: 3), "... much research has been undertaken in the past without the sanction or prior informed consent of Indigenous peoples, traditional societies and local communities and that such research has caused harm and adversely impacted their rights and responsibilities to biocultural heritage." In short, seeking the permission of Indigenous and local communities prior to conducting research can help to avoid perpetuating past injustices and help build true collaborative partnerships for the future (ISE 2006).

There are a broad range of public and private institutions involved in ethnobiological research initiatives, including universities, botanic gardens, museums, government agencies, non-governmental organizations (NGOs), and private corporations. As Laird and Wynberg (2002) note, most institutions sponsoring biodiversity research and prospecting do not have formal written policies or guidelines monitoring field research or benefit sharing but instead rely on long-standing practices understood by researchers as "best practice." In response to the Convention on Biological Diversity, however, many institutions have developed or are in the process of developing more formal institutional policies such as the initiatives detailed in Laird and Wynberg (2002). Regardless, it behooves the ethnobiological researcher to seek out information regarding the institutional policies of their sponsoring organization for research involving biocultural diversity or resources prior to conducting any field research.

For university researchers (e.g., faculty members, graduate students, research associates, etc.) in the United States, institutional review boards (IRBs) oversee research conducted in the social sciences, including ethnobiological and anthropological research. Before starting any research activities, IRBs often require researchers to pass training courses on ethics and submit proposals for review and revision. Researchers who fail to comply with IRB requirements risk sanctions including denial of promotion, funding, and/or degrees (Schrag 2009). Unfortunately, the provisions set forth by most IRBs are designed primarily to target medical and psychological research and in so doing give little consideration to the type of research initiatives commonly undertaken by ethnobiologists and the Indigenous and local communities that they engage (Eshbaugh 2008). Research ethics standards at Canadian universities are set by the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* which, like US regulations, requires Canadian universities to have research ethics boards which evaluate research involving humans (Bannister 2005).

Ethnobiologists must obtain the proper permits and permission from host country governments and institutions prior to conducting their research activities (Alexiades 1996; ISE 2006). This often requires applying for permits to work with Indigenous communities as well as to collect and export biological specimens. Compliance with the rules and regulations of host country governments and institutions is of the utmost importance and it is expected that researchers will uphold the principle of PIC. PIC, as defined by Laird and Noejovich (2002: 190), "broadly means the consent of a party to an activity that is given after receiving full disclosure regarding the reasons for the activity, the specific procedures the activity will entail, the potential risks involved and the full implications that can realistically be foreseen." Importantly, in regard to working with genetic resources, the need to receive PIC from host governments before conducting research is explicitly stated in Article 15.5 of the Convention on Biological Diversity (Laird 2002; Laird and Noejovich 2002). Failure to seek government permission and obtain official government permits justifiably fuels thoughts and concerns over biopiracy, neocolonialism, and researcher arrogance, among others. To eliminate unnecessary speculation regarding researcher compliance with government regulations, all publications should formally acknowledge permit approval by citing the appropriate permit number (Cunningham 1996).

Prior to initiating any field research or activities, ethnobiologists are also required to obtain PIC from the Indigenous and local communities with whom they seek to collaborate (ISE 2006; Laird and Noejovich 2002). Obtaining PIC from communities requires the researcher to provide full and honest disclosure of the project objectives, researcher identities, institutional sponsors, research methods, potential benefits and risks, plans for the dissemination of research results, funding sources, and any commercial interests, among others (ISE 2006; Laird and Noejovich 2002; Posey and Dutfield 1996). The International Society of Ethnobiology *Code of Ethics* (ISE 2006) states that community consent is ideally documented in writing and/or via tape recording. Importantly, Indigenous peoples' groups have articulated their desire for PIC through a wide variety of declarations and statements over the years (Dutfield 2002). Additionally, in these same declarations and statements they have also declared it their right to veto proposed research projects and access to their territories, resources, or knowledge.

It is important to note that PIC should not be considered a single-step process. PIC should be sought prior to the initiation of the research project, and then consultation and disclosure should be an ongoing, dynamic, and interactive process throughout the life of the project to ensure true negotiation of consent (Alexiades and Peluso 2002; ISE 2006; Laird and Noejovich 2002). This is especially true given that it is often difficult to properly communicate and explain the principles of PIC and the research process due to the fact that they are often complex and foreign concepts, outside the cultural experiences of many Indigenous and local groups (Alexiades and Peluso 2002; Eshbaugh 2008; FSI and Kothari 1997; Guerin-McManus and Kim 2002). Thus, for researchers engaging with an Indigenous or local group for the first time, it is recommended that they enlist the help of individuals or organizations more culturally and linguistically familiar with the group and/or that they use a step-wise research process where different parts of the research process are sequentially introduced and given permission (Alexiades and Peluso 2002). An ongoing and interactive consultative process is also recommended because, as Alexiades and Peluso (2002) note, it is difficult for researchers to foresee all of the potential implications and risks associated with research activities at the onset of a project, the asymmetrical power that exists between researchers and research participants makes achieving true negotiation regarding consent difficult, and identifying the various stakeholders present within communities at the beginning of a project can be problematic.

Cultural norms such as communal institutions, systems of exchange, and local decision making processes *must* also be respected and empowered for true negotiation of consent to occur (Alexiades and Peluso 2002; Laird and Noejovich 2002). To increase success, PIC consultations should also reflect community diversity and should be inclusive of the different groups (e.g., women, men, elders, clans, extended families, healers, fishers, hunters, etc.) that are present within a community. This will ensure a diversity of opinions, concerns, and points of view regarding the proposed research project (Alexiades and Peluso 2002; Laird and Noejovich 2002). In addition, after receiving initial community PIC for the research project, researchers need to obtain PIC from each individual research participant engaged throughout the course of the research project. An ongoing and interactive consultation and disclosure process with individual research participants is also required to ensure complete understanding and to obtain true consent.

Drafting a research agreement between the researcher and the community is also encouraged to further clarify and define research relationships (ISE 2006; Laird and Noejovich 2002). The research agreement should be in a format and language understandable to all parties and, if permitted by the community, should be in writing and/or tape-recorded (ISE 2006). Laird and Noejovich (2002) provide detailed recommendations regarding the key

elements of research agreements for academic projects, including sections addressing project principles and objectives, the process by which agreement was reached, responsibilities of the researcher, responsibilities of local communities, benefit sharing, conditions attached to collected information, and reporting, monitoring and evaluation, among others. Although this represents an investment of time on behalf of the researcher, as Laird and Noeovich (2002: 204) note, “In most cases, written agreements should not make the research process unnecessarily bureaucratic and restrictive for ethical and conscientious researchers. If relationships are well defined, resulting from an effective consultation process, drafting a written agreement should be straightforward and quite simple.”

Importantly, the extent and format of the research agreement will vary based on the nature, scale, and intent of the research project (Laird and Noeovich 2002). For example, research projects that are larger in size and scope, require extensive collecting of biological specimens, or are participatory and community-based in nature, will require greater investments of time and energy in developing a research agreement. Regardless, there is a need for flexibility in research agreements given the dynamic nature of research projects (Laird and Noeovich 2002), especially those that are participatory and community-based. Additionally, for general principles and recommendations regarding commercial research agreements and contracts please see Tobin (2002) and Gollin (2002).

2. Have You Thought About and Incorporated Local Needs, Challenges, and Priorities into the Research Project?

It is simply not enough just to inform Indigenous and local communities of ethnobiological research activities but instead it is necessary to include them in all aspects of the research process, including project design, implementation, reporting, and evaluation (Alexiades and Laird 2002; ISE 2006). As Cunningham (1996: 20) states, there is a “need to conduct research *with* local people rather than purely *for* or *about* them.” Ultimately, this helps make research more accountable to the needs, priorities, and challenges of host communities. Significantly, recognizing the need for more participatory and community-based research methodologies is closely in line with calls by Indigenous peoples’ groups for active participation in the research process and more equitable research partnerships (Dutfield 2002).

The unprecedented decline and loss of global biocultural diversity (Maffi 2001) also highlights the need for more participatory and community-based projects within Indigenous and local communities. As previously stated, ethnobiological researchers often work in areas and communities experiencing enormous sociocultural and environmental change and therefore they are on the front line of the loss of biocultural diversity. In short, there is a moral, ethical, and scientific imperative for ethnobiologists to develop participatory, community-based, and applied projects targeting the biocultural needs, challenges, and priorities of these communities. Significantly, due to the fact that ethnobiologists are trained to navigate the interface of the cultural and biological realms, they are ideally suited for developing the requisite interdisciplinary and multidisciplinary projects.

Unfortunately, as the need to develop participatory and community-based biocultural conservation projects continues to grow, as Alexiades and Laird (2002: 14) state, “academic advancement criteria have not changed, and the type of applied, multidisciplinary research most valuable for conservation and development in host countries and communities is poorly rewarded, and often even discouraged (Orr 1999).” Perhaps this helps to explain the fact that, while academic ethnobiologists continue to lament the general loss of global

biocultural diversity, most of their publications and conference presentations omit any mention of how their research projects are locally impacting biocultural conservation or affecting change. Or, at least, this is a more palatable explanation than assuming that the needed participatory and community-based biocultural conservation projects are not being developed and implemented.

Beyond potentially positively impacting the conservation of biocultural diversity, participatory and community-based research can also make projects more relevant and empowering to local communities and individuals (Alexiades 1996, 2003; FSI and Kothari 1997). Additionally, it can ultimately help to foster more equitable research partnerships, transforming host communities into full and equal partners in all aspects of the research process. It is also critically important that researchers remain cognizant of how their research projects can assist broader regional and national biocultural conservation efforts. In addition, many ethnobiological studies can help to provide baseline data for such international initiatives as the Convention on Biological Diversity's Global Strategy for Plant Conservation (GSPC) whose main goal is to halt the loss of plant diversity worldwide (Simmonds 2009). Therefore, it is critically important that researchers contact the appropriate host country institutions and organizations to determine how or if they can assist with a broader biocultural conservation agenda.

3. Who is Benefiting from the Research and How are Collaborating Communities and Individuals Being Compensated?

There is little doubt that Indigenous and local communities and individuals have a right to benefit from research on or about their knowledge, resources, and territories. Intellectual property rights (IPR)—the use of patents, copyrights, trade secrets and trademarks to protect knowledge and innovations from outside use without adequate consent or compensation—have been suggested as a mechanism to protect traditional knowledge from misappropriation or commodification and/or to exact compensation for commercial use of such knowledge. As Posey notes (2002: 9), there are limitations and inadequacies of IPR with regard to the protection of traditional knowledge and community resources. These include: they “require individual, not collective rights; require a specific act of ‘invention’; simplify ownership regimes; stimulate commercialization; recognize only market values; are subject to economic powers and manipulation; are difficult to monitor and enforce; [and] are expensive, complicated, [and] time-consuming.” Brush (1993, 1998, 2004) has also argued that monetary compensation via IPR may in fact cause more harm than good in certain situations and cultures. Most importantly for our discussion, FSI and Kothari (1997) stress that IPR is focused on protection from or obtaining compensation for commercial use of knowledge and that compensation, if it happens, usually takes place long after research has been completed and is not included as an integral part of the research process.

Although IPR may be an important mechanism for compensation in certain situations, due to the limitations of IPR described above and the need to compensate Indigenous and local communities for benefits obtained from a non-commercial research process, FSI and Kothari (1997: 127) “argue for integrating compensation and empowerment into the heart of the research process rather than viewing them as post-project undertakings.” Significantly, the reasons for compensation and benefits from a non-commercial research process are many. Perhaps most important is the fact that, although most academic and

non-commercial research projects do not directly lead to monetary or material benefits for the researcher, they often directly or indirectly lead to post-graduate degrees, grants, fellowships, publications, awards, and professional advancement, among many others, all of which ultimately contribute to material or monetary gains (FSI and Kothari 1997; Laird et al. 2002).

In short, we strongly feel that the most appropriate and effective way to integrate compensation and empowerment directly “into the heart of the research process” is by developing participatory, community-based, and applied projects with host communities. These projects can take a variety of forms, including sustainability studies on non-timber forest products (e.g., Endress et al. 2004), community-based medicinal plant projects (e.g., FSI and Kothari 1997), or participatory mapping projects focused on documenting ancestral territories, gathering and guarding traditional knowledge and illustrating resource use patterns (see Case Study 4.1), among many other examples. Notably, the common thread of all of these projects is that they are targeting the biocultural needs, priorities, and challenges of Indigenous and local communities resulting in concrete and clear benefits for these groups. Additionally, many participatory, community-based, and applied projects can also include significant capacity building and training components for participating communities and individuals which are key elements of any ethically grounded research initiative (ISE 2006).

4. How Will the Results of the Research Project be Shared and Used?

No project is complete until the results have been shared. Deciding how and who the results should be shared with is a key question before moving forward. Potential entities to share research results with include participating communities and individuals, host country governments, policy-makers, non-governmental organizations, and the academic community. Unfortunately, researchers generally consider the research process complete upon publication of research results, which is more often than not in academic journals (Shanley and Laird 2002). As Shanley and Laird (2002: 102) state, “The result is that most information and scientific understanding generated by researchers remains in the hands of scientists, academics and policy-makers geographically and conceptually distant from the region of study.” Thus, research results often do not reach local communities where research was conducted and where the information is often needed most. Additionally, if research results are shared with local communities, they are often in inappropriate formats (i.e., translations of academic publications, etc.), making them extremely limited in value. Therefore, not only is there a need to develop participatory, community-based and applied research projects with Indigenous and local communities, but there is an urgent need for researchers to return research results in formats that are relevant to these communities and their biocultural needs, priorities, and challenges.

As Shanley and Laird (2002) note, there are a variety of ways in which research results can be converted into forms that are relevant to Indigenous or local communities and other stakeholders. These include written and oral or in-person formats. Written materials may take the form of manuals, illustrated booklets, posters, curricula materials for schools, coloring books for children, and technical books. Oral or in-person formats may include interactive seminars and workshops, exchanges between groups, theater and traveling shows, role playing, videos, music, field courses, and lectures. The exact format that research results will take will be driven by overall objectives and the audience

or group that is being targeted (Shanley and Laird 2002). For example, the residents of isolated Indigenous or local communities may be semi-literate and therefore the oral or in-person formats described above along with illustrated booklets may be most appropriate, whereas it may be best to provide government officials with academic publications and technical books.

In short, sharing research results in an appropriate manner with the correct stakeholders can result in a variety of positive outcomes, including helping to foster conservation (Shanley and Laird 2002), validate or reaffirm Indigenous knowledge and cultures (Alexiades 2004; Laird et al. 2002), conserve and record threatened knowledge (Laird et al. 2002), facilitate territorial or management claims (Laird et al. 2002), and it can result in community empowerment (Shanley 1999). Unfortunately, although there are a whole host of positive outcomes related to appropriately sharing research results with Indigenous and local communities, some researchers will inevitably focus on the impediments to doing so. For example, some ethnobiological researchers may not have the necessary expertise and skills to accomplish this, yet this can be overcome by collaborating with individuals and/or organizations who do (Shanley and Laird 2002). Additionally, this requires both time and money which researchers oftentimes lack and returning research results to Indigenous and local communities in non-traditional formats is not encouraged or rewarded by academic advancement and promotion systems and criteria (Shanley and Laird 2002). However, as the International Society of Ethnobiology *Code of Ethics* (ISE 2006: 7) states:

... research and related activities should not be initiated unless there is reasonable assurance that all stages can be completed from (a) preparation and evaluation, to (b) full implementation, to (c) *evaluation, dissemination and return of results to the communities in comprehensible and locally appropriate forms*, to (d) training and education as an integral part of the project, including practical application of results. [emphasis added]

5. Are the Interests of Collaborating Communities and Individuals Being Acknowledged and Protected when Disseminating Research Results?

Although there are a variety of positive outcomes associated with sharing research results with stakeholders, it is important to remember that sharing results can also result in an assortment of potentially unintended negative consequences for Indigenous and local communities. For example, the publication or sharing of research results inappropriately can result in the misappropriation and commodification of the knowledge or resources of host communities by third parties, such as corporations, without appropriate consultation, permission, or compensation (Alexiades 2004; Laird et al. 2002; Milliken 2002). In fact, it has been found that literature and databases are important sources of information about natural products for pharmaceutical companies who use ethnobotanical information in research programs (ten Kate and Laird 1999). Additionally, the publication of biological information can sometimes endanger economically or culturally important species or habitats and sharing traditionally restricted types of specialized knowledge of individuals or groups within communities can threaten cultural stability (Laird et al. 2002).

Therefore, a tension exists between sharing information and acknowledging and protecting the rights, resources, and knowledge of Indigenous and local communities. For example, disciplinary norms, institutional expectations, and funding organizations often place considerable pressure on academic ethnobiological researchers to quickly, freely, and openly share research results via scientific publications which often is in conflict with providing host communities with greater control over this information or adequately

protecting it (Alexiades and Laird 2002; Laird et al. 2002). Additionally, these same tensions also exist when producing field guides of medicinal plants for communities (Milliken 2002) and sharing results from participatory mapping projects (see Case Study 4.1), among others, as this information can also be misappropriated without community consent. In short, there is a critical need for researchers to proceed with extreme caution before sharing research results and to strike a balance between professional expectations and the needs and interests of host communities. Individual researchers and communities have developed a variety of innovative ways to strike this balance, including restricting the disclosure of ethnobiological information to already published species, excluding species names from publications, forgoing the publication of select data, and restricting access to culturally sensitive data by outsiders (Laird et al. 2002).

In addition, it is necessary for ethnobiological researchers to understand that they must receive permission from host communities in order to publish information regarding their knowledge, resources, or territories. As stated in the International Society of Ethnobiology *Code of Ethics* (ISE 2006: 6), Indigenous and local communities “have the right to exclude from publication and/or to have kept confidential any information concerning their culture, identity, language, traditions, mythologies, spiritual beliefs or genomics. . . Indigenous peoples, traditional societies, and local communities also have the rights to privacy and anonymity, at their discretion.” To further protect and acknowledge the rights and ownership of host communities over their knowledge, resources, and territories it is also expected that they will be given credit for their contributions to research activities in all project publications or materials and will be afforded co-authorship when appropriate, unless anonymity has been requested (Alexiades 1996; Cunningham 1996; FSI and Kothari 1997; ISE 2006).

CASE STUDY 4.1 *Maps from the Forest: The Maijuna Participatory Mapping Project*

The Maijuna, also known as the Orejón, are an Amazonian Indigenous group presently found along the Sucusari, Yanayacu, and Algodón rivers of the northeastern Peruvian Amazon (Gilmore 2005, 2010). There are approximately 400 Maijuna individuals living in four communities located along the above-mentioned rivers. The residents of these communities employ a variety of subsistence strategies, including hunting, fishing, swidden-fallow agriculture, and the gathering of various forest products. All four communities are recognized as *Comunidades Nativas* (Native Communities) by the Peruvian Government and all have been granted title to parcels of land in which their respective communities are located (Brack-Egg 1998). Unfortunately, the titled land that the Maijuna have received is a very small portion of their ancestral territory. Therefore, hundreds of thousands of hectares of Maijuna traditional land within the Sucusari, Yanayacu, and Algodón watersheds, the vast majority of which is intact and undisturbed primary rain forest, currently remains unprotected (Gilmore 2010).

Today, Maijuna traditional lands within the Sucusari, Yanayacu, and Algodón watersheds, which comprise approximately 300,000 ha of primary rain forest, are under siege by illegal incursions from loggers, hunters, fishermen, and resource extractors from outside communities (Gilmore 2005, 2010). In addition, the Peruvian Government has recently proposed the construction of a road through Maijuna traditional and titled lands, which the Maijuna adamantly oppose, and has yet to properly consult the Maijuna about the proposed road and its potential biological and cultural ramifications (Gilmore 2010). These developments threaten to irreversibly alter Maijuna traditional lands and also their very way of life. In response to these and other threats to their biocultural resources, leaders from all four Maijuna communities took the initiative in 2004 to establish the *Federación de Comunidades Nativas Maijuna (FECONAMAI)*, a Maijuna Indigenous federation representing all four Maijuna communities (Gilmore 2010). The principle goals of FECONAMAI since its inception

are to (1) conserve the Maijuna culture, (2) conserve the environment, and (3) improve Maijuna community organization (FECONAMAI 2004, 2007).

From 2004 to 2009, M. Gilmore (whom has worked closely with the Maijuna since 1999) and his student J. Young collaborated with FECONAMAI on a community-based project using participatory mapping techniques as a tool to help conserve Maijuna traditional lands and their biocultural resources (see Gilmore and Young 2010). Participatory mapping consists of encouraging local people to draw maps of their lands that include culturally and biologically significant information (e.g., land-use data, resource distributions, and culturally, biologically, and historically significant sites) (Smith 1995; Herlihy and Knapp 2003; Corbett and Rambaldi 2009). Importantly, participatory mapping has been successfully used throughout the world by a variety of Indigenous and local communities for a wide range of purposes, including to establish past and present boundaries of occupied territory, form the basis of land claims, and defend communal territory from incursions by outsiders, among many others (Arvelo-Jiménez and Conn 1995; Chapin and Threlkeld 2001; Neitschmann 1995; Poole 1995).

After obtaining PIC from each of the four Maijuna communities and receiving input with regard to project design and implementation, community meetings were held in each of the communities where participants drew detailed maps of their traditional and titled lands. These maps included hundreds of culturally and biologically significant sites, including old and new house sites and swiddens, past and present cemeteries, locations of ancient Maijuna battles, and hunting, fishing, and plant collecting sites, among many others. Upon completion of each map, a team of Maijuna cultural experts was selected in each community to work with the researchers to visit and fix the location of as many of the identified sites as possible using hand-held global positioning system (GPS) units (Chapin and Threlkeld 2001; Sirait et al. 1994). Additionally, while in the field, key and detailed information pertaining to the ethnohistory, traditional stories, and resource-use strategies for each site was also documented via ethnographic interviewing techniques and recorded using voice recorders, cameras, and video cameras. Ultimately, the field teams located and fixed the geographical coordinates of over 900 culturally and biologically significant sites within the Sucusari, Yanayacu, and Algodón river basins (Gilmore and Young 2010).

Upon returning from the field, the data collected was integrated, organized, analyzed, and spatially represented using ArcGIS, a geographic information systems (GIS) software package (Corbett and Rambaldi 2009; Duncan 2006; Elwood 2009; Scott 1995; Sirait et al. 1994). The maps produced from this phase of the research project have been shared with the Maijuna and they have requested that they be shared with the Gobierno Regional de Loreto (GOREL), the Regional Government of the Peruvian Amazon, in the hope that they will be used to help justify the establishment of an Área de Conservación Regional (ACR; Regional Conservation Area), which would formally protect Maijuna traditional and titled lands. Significantly, the creation of an ACR that would legally and formally protect Maijuna ancestral lands and resources in perpetuity is the number one goal of FECONAMAI and they are currently and actively petitioning GOREL for its creation (Gilmore 2010).

The results of this community-based project have also been shared with and used by the Maijuna in other ways. For example, copies of the hand-drawn maps produced in each of the different Maijuna communities have been returned to them. Two different versions of each of these maps have been provided to the Maijuna at their request. One version of each map contains all of the information drawn on the original, while the other version was altered to omit information that they consider and have designated as culturally sensitive and important. According to the Maijuna, the map with the culturally sensitive and important information will only be made available to Maijuna individuals, whereas the altered version may be shared with visitors from outside communities. This ultimately helps to protect against the misappropriation and commodification of this information by outside resource extractors and other nefarious individuals. The Maijuna plan to use the unedited maps to teach their children the geographic and traditional knowledge embedded within them. This is critically important given that many Maijuna children do not know the traditional Maijuna names and locations of the various rivers, streams, and other culturally and biologically significant places and sites within their traditional lands. Therefore, these maps can serve as critical and much needed teaching tools.

It is also important to note that some challenges exist with regard to sharing the information collected during the course of this community-based project in culturally appropriate and relevant formats and ways with the Maijuna. For example, the researchers are currently working to integrate the ethnohistorical and cultural information obtained via the ethnographic interviews completed in the field into the GIS database described above. This will require uploading, organizing, and integrating hundreds of interviews, photographs, and videos, ultimately developing a multimedia participatory GIS (PGIS) database that will serve as a reservoir of Maijuna traditional knowledge and beliefs regarding their ancestral lands and the biocultural resources found within them. This is critically important given that Maijuna elders and leaders would like to use this repository of information in cultural preservation and revitalization programs. However, the main challenge will be how to make this happen effectively, given that the Maijuna do not currently have the technological resources or skills necessary to access and use such a PGIS database. In short, the researchers will have to continue to work with the Maijuna to reconcile their needs, challenges, and priorities with the dataset at hand.

CONCLUSION

In conclusion, there are a myriad of ethical challenges and issues facing the ethnobiological researcher while working with Indigenous and local communities. We have proposed a series of five questions to provide a framework for decision making and conduct to help ethnobiologists navigate this multidimensional and complex ethical landscape. These questions point to the need for the field of ethnobiology to shift toward more participatory, community-based, and applied research projects, ultimately moving toward more equitable partnerships with both Indigenous and traditional communities. We envision “the researched” or the “subject population” becoming full and equal partners in all aspects of the ethnobiological research process. We view this approach as a more ethical research model and an absolutely necessary step if the field of ethnobiology is to have any meaningful role in addressing and stopping the loss of global biocultural diversity. In short, it is important for ethnobiologists to strengthen their research ethics by critically reflecting on their purpose in doing research and asking who is empowered by their projects.

ACKNOWLEDGMENTS

First and foremost, we would like to acknowledge and thank the Maijuna people for their many intellectual contributions over the years as many of the ideas and concepts detailed in this paper were formulated in collaboration with them. Financial support for research with the Maijuna since 1999 was provided by Miami University, George Mason University, The Rufford Small Grants Foundation, the National Science Foundation, the Elizabeth Wakeman Henderson Charitable Foundation, and Phipps Conservatory and Botanical Gardens (Botany in Action). Additionally, we would like to thank Adolph M. Greenberg, Jason C. Young, and Jyl M. Lapachin for their varied intellectual contributions.

REFERENCES

- ALEXIADES MN. Protocol for conducting ethnobotanical research in the tropics. In: ALEXIADES MN, editor. Selected guidelines for ethnobotanical research: a field manual. New York: New York Botanical Garden; 1996. p 5–18.
- ALEXIADES MN. Ethnobotany in the third millennium: expectations and unresolved issues. *Delpinoa* 2003;45: 15–28.
- ALEXIADES MN. Ethnobiology and globalization: science and ethics at the turn of the century. In: CARLSON TJS,

- MAFFI L, editors. Ethnobotany and conservation of biocultural diversity. *Advances in Economic Botany*, Volume 15. New York: New York Botanical Garden; 2004. p 283–305.
- ALEXIADES MN, LAIRD SA. Laying the foundation: equitable biodiversity research relationships. In: LAIRD SA, editor. *Biodiversity and traditional knowledge: equitable partnerships in practice*. London: Earthscan; 2002. p 3–15.
- ALEXIADES MN, PELUSO DM. Annex 7.1: Prior informed consent: the anthropology and politics of cross-cultural exchange. In: LAIRD SA, editor. *Biodiversity and traditional knowledge: equitable partnerships in practice*. London: Earthscan; 2002. p 221–227.
- ARVELO-JIMÉNEZ N, CONN K. The Ye'kuana self-demarkation process. *Cult Surv Quart* 1995;18(4):40–42.
- BANNISTER K. Use of traditional knowledge for university research: conflicts between research ethics and intellectual property ownership policies. In: ARNASON JT, CATLING PM, SMALL E, DANG PT, LAMBERT JDH, editors. *Biodiversity and health: focusing research to policy*. Proceedings of the International Symposium held in Ottawa, Canada, 25–28 October 2003. Ottawa: NRC Research Press; 2005. p 122–129.
- BOOM BM. Ethics in ethnopharmacology. In: ELIZABETSKY E, editor. *Proceedings of the First Congress of Ethnobiology*. Belem: Museu Paraense Emilio Goeldi; 1990. p 147–153.
- BRACK-EGG A. Amazonia: biodiversidad, comunidades, y desarrollo [CD-ROM]. Lima: DESYCOM (GEF, PNUD, UNOPS, Proyectos RLA/92/G31, 32, 33, and FIDA); 1998.
- BRUSH SB. Indigenous knowledge of biological resources and intellectual property rights: the role of anthropology. *Amer Anthropol* 1993;95:653–686.
- BRUSH SB. Bio-cooperation and benefits of crop genetic resources: the case of Mexican Maize. *World Devel* 1998;26:755–766.
- BRUSH SB. *Farmers' bounty: locating crop diversity in the contemporary world*. New Haven (CT): Yale University Press; 2004.
- CHAPIN M, THRELKELD B. *Indigenous landscapes: a study in ethnocartography*. Arlington (TX): Center for the Support of Native Lands; 2001.
- CORBETT J, RAMBALDI G. Geographic information technologies, local knowledge, and change. In: COPE M, ELWOOD S, editors. *Qualitative GIS: a mixed methods approach*. London: Sage Publications; 2009. p 75–92.
- CUNNINGHAM AB. Professional ethics and ethnobotanical research. In: ALEXIADES MN, editor. *Selected guidelines for ethnobotanical research: a field manual*. New York: New York Botanical Garden; 1996. p 19–51.
- DUNCAN SL. Mapping whose reality? *Geographic Information Systems (GIS) and "wild science"*. *Pub Understand Sci* 2006;15(4):411–434.
- DUTFIELD G. Annex 7.2: Indigenous peoples' declarations and statements and equitable research relationships. In: LAIRD SA, editor. *Biodiversity and traditional knowledge: equitable partnerships in practice*. London: Earthscan; 2002. p 228–232.
- ELWOOD S. Multiple representations, significations, and epistemologies in community-based GIS. In: COPE M, ELWOOD S, editors. *Qualitative GIS: a mixed methods approach*. London: Sage Publications; 2009. p 57–74.
- ENDRESS BA, GORCHOV DL, PETERSON MB, SERRANO EP. Harvest of the palm *Chamaedorea radicalis*, its effects on leaf production, and implications for sustainable management. *Conserv Biol* 2004;18:822–830.
- ESHBAUGH WH. A dilemma: economic/ethnobotanical research in the twenty-first century. *Econ Bot* 2008; 62(1):3–11.
- FECONAMAI. Libro de Actas No 1 de la Federación de Comunidades Nativas Majuna (FECONAMAI). Puerto Huamán, Loreto, Perú; 2004.
- FECONAMAI. Constitución de la asociación denominada Federación de Comunidades Nativas Majuna (FECONAMAI). Iquitos: Foinquinos-Mera; 2007.
- FUNDACIÓN SABIDURÍA INDÍGENA (FSI), KOTHARI B. Rights to the benefit of research: compensating indigenous peoples for their intellectual contribution. *Hum Organ* 1997;56(2):127–137.
- GILMORE MP. *An ethnoecological and ethnobotanical study of the Majuna Indians of the Peruvian Amazon [PhD Dissertation]*. Oxford (OH): Miami University; 2005.
- GILMORE MP. The Majuna: past, present, and future. In: GILMORE MP, VRIESENDORP C, ALVERSON WS, DEL CAMPO A, VON MAY R, LÓPEZ WONG C, RÍOS OCHOA S, editors. *Perú: Majuna. Rapid Biological and Social Inventories Report 22*. Chicago (IL): Field Museum; 2010. p 226–233.
- GILMORE MP, YOUNG JC. The Majuna participatory mapping project: mapping the past and the present for the future. In: GILMORE MP, VRIESENDORP C, ALVERSON WS, DEL CAMPO A, VON MAY R, LÓPEZ WONG C, RÍOS OCHOA S, editors. *Perú: Majuna. Rapid Biological and Social Inventories Report 22*. Chicago (IL): Field Museum; 2010. p 233–242.
- GOLLIN MA. Elements of commercial biodiversity prospecting agreements. In: LAIRD SA, editor. *Biodiversity and traditional knowledge: equitable partnerships in practice*. London: Earthscan; 2002. p 310–332.
- GUERIN-MCMANUS M, KIM D. Annex 7.3: Prior informed consent: protocol and form. In: LAIRD SA, editor. *Biodiversity and traditional knowledge: equitable partnerships in practice*. London: Earthscan; 2002. p 233–236.
- HERLIHY PH, KNAPP G. Maps of, by, and for the peoples of Latin America. *Hum Organ* 2003;62(4):303–314.
- INTERNATIONAL SOCIETY OF ETHNOBIOLOGY (ISE). *International Society of Ethnobiology Code of Ethics (with 2008 additions)*. 2006. Available at http://www.ethnobiology.net/_common/docs/ISE%20COE_Eng_rev_24Nov08.pdf.
- LAIRD SA. Introduction: equitable partnerships in practice. In: LAIRD SA, editor. *Biodiversity and traditional knowledge: equitable partnerships in practice*. London: Earthscan; 2002. p xxii–xxxvi.
- LAIRD SA, NOEJOVICH F. Building equitable research relationships with indigenous peoples and local communities: prior informed consent and research agreements. In: LAIRD SA, editor. *Biodiversity and traditional knowledge:*

- equitable partnerships in practice. London: Earthscan; 2002. p 179–238.
- LAIRD SA, WYNBERG R. Institutional policies for biodiversity research. In: LAIRD SA, editor. Biodiversity and traditional knowledge: equitable partnerships in practice. London: Earthscan; 2002. p 39–76.
- LAIRD SA, ALEXIADES MN, BANNISTER KP, POSEY DA. Publication of biodiversity research results and the flow of knowledge. In: LAIRD SA, editor. Biodiversity and traditional knowledge: equitable partnerships in practice. London: Earthscan; 2002. p 77–101.
- MAFFI L, editor. On biocultural diversity: linking language, knowledge, and the environment. Washington (DC): Smithsonian Press; 2001.
- MILLIKEN W. Case study 4.1: People, plants, and publishing. In: LAIRD SA, editor. Biodiversity and traditional knowledge: equitable partnerships in practice. London: Earthscan; 2002. p 79–81.
- NEITSCHMANN B. Defending the Miskito Reefs with maps and GPS: mapping with sail, scuba, and satellite. *Cult Surv Quart* 1995;18(4):34–37.
- ORR DW. Education, careers, and callings: the practice of conservation biology. *Conserv Biol* 1999;13(6):1242–1245.
- POOLE P. Land-based communities, geomatics, and biodiversity conservation. *Cult Surv Quart* 1995;18(4):74–76.
- POSEY DA. Commodification of the sacred through intellectual property rights. *J Ethnopharmacol* 2002;83:3–12.
- POSEY DA, DUTFIELD G. Beyond intellectual property: towards traditional resource rights for indigenous peoples and local communities. Ottawa: IDRC; 1996.
- SCOTT D. Habitation sites and culturally modified trees. *Cult Surv Quart* 1995;18(4):43–48.
- SCHRAG ZM. How talking became human subjects research: the federal regulation of the social sciences, 1965–1991. *J Pol Hist* 2009;21(1):3–37.
- SHANLEY P. Extending ecological research to meet local needs: a case from Brazil. In: SUNDERLAND TCH, CLARK LE, VANTOMME P, editors. Non-wood forest products of Central Africa: current research issues and prospects for conservation and development. Rome: Food and Agriculture Organization of the United Nations; 1999. p 99–108.
- SHANLEY P, LAIRD SA. ‘Giving back’: making research results relevant to local groups and conservation. In: LAIRD SA, editor. Biodiversity and traditional knowledge: equitable partnerships in practice. London: Earthscan; 2002. p 102–124.
- SIMMONDS MSJ. Opportunities and challenges for ethnobotany at the start of the twenty-first century. In: OSBOURN AE, LANZOTTI V, editors. Plant-derived natural products. New York: Springer; 2009. p 127–140.
- SIRAIT M, PRASODJO S, PODGER N, FLAVELLE A, FOX J. Mapping customary land in East Kalimantan, Indonesia: a tool for forest management. *Ambio* 1994;23(7):411–417.
- SMITH RC. GIS and long range economic planning for indigenous territories. *Cult Surv Quart* 1995;18(4):43–48.
- TEN KATE K, LAIRD SA. The commercial use of biodiversity: access to genetic resources and benefit-sharing. London: Earthscan; 1999.
- TOBIN B. Biodiversity prospecting contracts: the search for equitable agreements. In: LAIRD SA, editor. Biodiversity and traditional knowledge: equitable partnerships in practice. London: Earthscan; 2002. p 287–309.

Chapter 5

The World According to Is'a: Combining Empiricism and Spiritual Understanding in Indigenous Ways of Knowing

RAYMOND PIEROTTI

Ecology and Evolutionary Biology and Global Indigenous Nations Studies, University of Kansas, Lawrence, KS

BEING NATIVE TO A CHANGEABLE PLACE	69
THE CONCEPT OF PERSONHOOD	72
ATTITUDES TOWARDS PREDATORS	74
THE NATURE OF CREATORS	76
REFERENCES	79

Nature speaks in many tongues and they are all alien. What a scientist tries to do is decipher these dialects.

— slightly modified from Dudley Herschbach (Harvard),
quoted in Bain (2004: 144)

I am particularly fond of the quote above, because I think it can be applied to any individual from any cultural tradition who is involved in trying to figure out how the world works and their place in it as a human being. All humans struggle with the mysteries of the Earth, the universe, and what it means to be human. They face these struggles initially with a combination of ignorance and curiosity and, if they are self aware and insightful, with a mixture of respect and caution.

The question I address is how human beings from various intellectual and cultural traditions deal with such intellectual and spiritual struggles. It is important to realize that these struggles are both intellectual and spiritual, because the latter factor is often downplayed in

the Western tradition, although most insightful scholars recognize this duality. I hope to demonstrate that the methods and insights developed by Indigenous cultures are as powerful and useful in trying to understand the workings of the Earth and the nature of reality as any other intellectual tradition, including what is known as “Western science” and the “scientific method,” and that a major strength of the Indigenous approach is the integration of the spiritual aspects of knowledge.

All intellectual traditions depend on the use of metaphor to model and investigate natural phenomena. “. . . [S]cientific understanding, like all human understanding, proceeds by way of providing metaphorical re-descriptions of phenomena” (Hesse 1974: 62). However, when the metaphors involved come from Indigenous cultures they are all too often dismissed as mere “stories” or “legends” (Deloria 1992; Pierotti 2011; Pierotti and Wildcat 2000). This is disrespectful and almost certainly racist, because these Indigenous metaphors are derived from careful observation of relationships, between humans and nonhumans and among non-human components of ecosystems, which lead to the basic Indigenous principles that “all things are connected,” and “all things are related.”

Individuals of European ancestry often regard these basic principles as being somewhat “mystical” and analogous to myth (Pierotti 2011; Pierotti and Wildcat 2000). They are not; in fact these might well be recognized by people trained in the biological sciences as the fundamental principles of ecology and evolutionary biology, respectively.

When I was a graduate student in Canada, I was asked to design an examination exercise for a final in an introductory course in Biological Sciences. I asked students to assemble a food web for the Georgia Strait off the coast of British Columbia. One of the professors in charge of the course argued that this was not an appropriate question because “any intelligent person could answer it.” I was teaching my students the importance of understanding connection and relationships among species, whereas the faculty member seemed to think that connection was an obvious aspect of human awareness, and not of importance in the biological sciences.

The problem in this particular instance, as well as in much of the confusion that results from comparing Western scientific results and Indigenous observations, is that since the Enlightenment the traditional model of nonhuman organisms in the Western scientific tradition has been the Cartesian metaphor of the machine, which considers organisms, and even ecosystems, to be of interest primarily through the study of their constituent parts (Pierotti 2011). According to this metaphor, the most effective way to understand the natural world is by understanding its constituent parts and how they fit together (Coates 1998; Lewontin 2001). One scholar says of Western science, “The entire system is totally, intensely conservative, locked into itself, utterly impervious to any ‘hints’ from the outside world. . . . This system obviously defies ‘dialectical’ description. It is not Hegelian at all, but thoroughly Cartesian” (Monod 1979: 108). Over the last 300 years this machine-based analytic approach has been successful in explaining some aspects of nature, but it has also led to an oversimplified view of the relation of parts to wholes and causes to effects (Lewontin 2001; Pierotti 2011).

The Western “scientific” tradition seeks “global” solutions, that is, results that can be generalized across all localities. This leads to a problem in that solutions and results which are often assumed to be global in scope turn out instead to be local. When I was an undergraduate in the early 1970s I listened to an acrimonious debate between two graduate students, one of whom studied Steller sea lions, *Eumetopias jubatus*, in Alaska, while the other studied the same species in California. The investigator who worked in Alaska insisted that parental care lasted for more than a year in this species whereas the California investigator insisted with equal assurance that offspring were weaned at the age of 3–4 months.

Each insisted that their view of parent–offspring relationships in these sea lions was correct and that the other must be wrong. When I suggested that they both might be right and that ecological conditions in different locations might require different responses, both investigators dismissed me as a naive undergraduate who “did not understand how science worked.”

Both were correct—harsher environmental conditions in Alaska favored extended parental care, whereas the milder California environment allowed sea lions to wean their young at younger ages. To me as a larval-stage scientist, this debate revealed the limitations of the Western typological, single “global solution” approach to science and the idea that species were the same wherever they occurred. The true irony was that, given the proclivity of Indigenous peoples to accept unusual observations and incorporate them in their understanding of the world, if an Aleut from Alaska met with a Yurok from California and presented these differing results, each would have completely accepted the statements made by the other as factual, and each would have presented a solid explanation based upon their knowledge of local environmental conditions.

The point is that the worldview, the way individuals see the world, has a major impact on the way they interpret it. In the intellectual and philosophical traditions of the Indigenous peoples of North America no question is off limits. The observations on which knowledge of a local system is based are so careful and detailed that any aspect of relationships can be discussed, among humans, between human and nonhuman, among nonhuman, etc. (see also Barsh 2000). It is crucial to keep in mind, however, that this knowledge would only be applicable to local humans and nonhumans, that is, those that came from and shared the same “place” (Anderson 1996; Basso 1996; Kidwell and Velie 2005).

Knowledge held by Indigenous people is specific, but also very accurate. It may often be superior to Western science in its ability to predict local phenomena. Both are valid forms of “science” or “ways of knowing,” but the scale at which they can be applied may differ. Despite this emphasis on “local” knowledge, the knowledge base and techniques of different groups of Indigenous peoples share similar philosophical and conceptual themes (Pierotti 2011; Pierotti and Wildcat 2000). These shared themes emerge from similar attitudes towards the nature of relationships and relatedness that exist within and between social and ecological communities.

Indigenous perspectives are most effective in observing and understanding wholes rather than parts, because they operate at the level of human perception and concentrate on functional relationships and coevolutionary processes rather than internal structure (Barsh 1997, 2000). Indigenous intellectual and philosophical traditions largely ignore the structure of matter at the cellular and molecular levels. Instead they emphasize relationships between species, responses to environmental variation, or the role of individual variation in population dynamics. To employ the metaphor from the epigram, Indigenous people pay more attention to deciphering the dialects and understanding what messages can be discerned from the natural world, without feeling the need to break it down into its constituent parts. They learn to understand the language, but are not simply linguists. Western science would seem in many cases to be more concerned with the muscles that make up the tongue, and how the words are formed, than their actual meaning.

The knowledge acquired through these communications from nature is typically embodied in the form of stories that derive from metaphoric interpretations of natural relationships. The stories of Indigenous Americans function both as information about ecological and evolutionary relationships, and as instructions about ethical and moral behavior, because they emerge from an understanding of relationships between species. One example of this dual function is the relationship between wolf (I'sa) and coyote (Tseena or I'sa'pu) in the

tales of Numic peoples, including Utes, Paiutes, Shoshones and Comanches. To begin with, Wolf and Coyote are described as brothers (Lily Pete, in Smith 1993: 3; see also Papanikolas 1995; Ramsey 1977), which is a metaphor that establishes the evolutionary relationship and shared ancestry between these two closely related species within the genus *Canis*. Second, both Wolf and Coyote are also characterized as good hunters, although Wolf is considered to be a much better hunter. For example, Wolf is capable of taking adult deer whereas Coyote takes primarily fawns, along with rabbits and rats (Lily Pete, in Smith 1993: 5; Johnny Dick, in Smith 1993: 91), which accurately characterizes the ecological roles of these two species. Thus both the ecological and evolutionary relationships among species are crucial aspects of the metaphor and of the stories that are derived from it.

To establish an ethical and moral perspective in these stories, Wolf and Coyote are often shown as arguing about how the world should function. Wolf is represented as a kind elder sibling or parent, who desires a world in which death is only temporary, childbirth is easy and pleasant for women, and winter does not exist. In contrast, Coyote, the impudent younger sibling or rebellious child, challenges his/her older brother/sister—arguing that death should be permanent, childbirth should be difficult, and hardships and cold weather should be regular aspects of human experience.

The interesting aspect of this dichotomy is that although Numic children are taught to emulate Wolf, and view Wolf as a much more sympathetic figure than Coyote, it is Coyote who presents the more realistic view of how the world truly functions (Pierotti 2011). Wolf is often frustrated by the actions of the various species in the world s/he has worked to put together. As an example:

When Creation was finished, Gray Wolf's children began to do wrong, they fought amongst themselves. Their father, Gray Wolf, became angry, and kicked them all out. He decided to go south; he said, "My children are not going to see me again!" Then his wife cried, "But my children are here!" But they went down to the water anyway, it is said, and walked away over its surface.

Gray Wolf and his wife came to a tall mountain, with a pine-covered summit. He said, "I am going in there; afterwards my children will see my tracks going in. Here I have come and left my tracks; Nuhmuhnuh will see them and so will white men." So it was.

Ramsey 1977: 231

Another such story from the Shoshone (Sosoni or Newa-nuh) of Nevada is told by an elder of the tribe.

You see, the coyote and the wolf were talking long ago. Wolf was arguing that we should all look alike, the rocks should be the same, the sagebrush the same, the humans the same, and all the living things on this planet should be the same. We should think alike and act alike and so forth.

But Coyote always said, "No, we should be all be different. We shouldn't look alike at all."

And so today we look around us and nothing looks alike. Rocks are not alike. Humans are not alike. This is the root of why we don't believe in each other. It's just as Coyote said. There's no use believing in just one thing. Let's not believe it. Let's all disagree, and everybody believe in different things. That's why I always say, it's easy to believe the bad things first, but the good thing is harder to believe and harder to come by. As Wolf said, "It's going to be really hard that way, because what you're saying is, let's not believe in each other."

So today, what Coyote said is what we've got. . . .

Harney 1995: 26

Numic people are children of I'sa, but siblings of I'sa'pu—they recognize that despite the suffering and tragedy that result from Coyote's vision, it is the way that things usually work. It is stated about Coyote's views about death and hardships that, "If it weren't for Coyote there would be too many people now" (Lily Pete, in Smith 1993: 3), which shows

a recognition of the risks of local human overpopulation on potentially limiting sources of food, water, etc.

One ironic twist in many of these stories is that despite his apparent realistic perspective, on those occasions when Coyote gets his way he almost invariably regrets the consequences of his actions. This allows Numic peoples to deal with a conundrum that confuses the best of people, that is, if there is a kind creator, how can bad things happen? Coyote is also a bit of a hypocrite, in that she seems to expect that the arguments she makes about how the world should function apply to everyone other than herself. In this way he is like humans, who bemoan the existence of suffering and sadness. Aspects of nature that appear cruel and arbitrary are inevitable consequences of existence, but often result from self-centered actions. Thus, humans are shown that in their own vain, selfish, ego-driven behavior they act more like Coyote, causing problems for themselves and the rest of the world, even though they are expected to try to emulate the idealism and good behavior shown by Wolf. Humans find themselves trapped by the real world and resent the sorrow and problems it presents them with, but these stories show them that such situations often result from situations that they themselves have created (Papanikolas 1995; Pierotti in press; Ramsey 1977).

Western philosophical traditions have a less nuanced dichotomous view of the natural world in which nature is either sentimentalized or treated as if it were cruel and destructive (Coates 1998). In this tradition, there is assumed to be a rival entity that tries to thwart the good efforts of the creator, and this entity is typically identified with the existence of “evil” (Pagels 1995; Pavlik 1997; Sagan 1995).

Indigenous knowledge yields a more subtle and nuanced understanding of the functioning of the natural world. One major difference is that carnivores are recognized as being powerful creatures, not unlike humans, and at least in the case of wolves, very similar to humans in the structure of their family units (Pierotti 2011, see below). In contrast to the social instincts of wolves, coyotes are recognized as more solitary and driven primarily by only their own concerns rather than those of other beings. This self-centered behavior causes problems, which can be somewhat alleviated through humans (or wolves) functioning as an integrated group where individuals work for the good of the group rather than individual ends.

BEING NATIVE TO A CHANGEABLE PLACE

Through at least the past 11,000 years, and some say much longer, the land has supported communities of people who have relied on the plants and animals of their home regions for survival. These people have since time immemorial for them, adapted their lifestyles to the changing climates and the fluctuations in abundance of fish, wildlife, and plants.

Turner 2005: 13–14

Indigenous Americans were almost certainly aware of the true nature of population and environmental fluctuations because, as Turner indicates, they kept constant track of the changeable non-equilibrium conditions that predominate in the real world. During the period when modern human beings were evolving over the last 100,000 years there have been only two generally stable periods of climate (Pearce 2007: 237). The first was when the ice sheets were largest, and the world was coldest. The second is the period in which we are living now. Ironically, the Western scientific tradition has existed primarily during this last period, and therefore treats the current set of environmental conditions as if they were typical and basically unchanging. This is one major reason why climate change disturbs and is often denied by people of European heritage—they have difficulty in imagining

a world that changes beyond their control. It has only been in the last 25 years that Western ecologists have begun to recognize the changeability of the natural world and to reject older models based on the metaphors of “balance of nature” and “equilibrium” communities and populations (Botkin 1990, 1991; Coates 1998: 186–191; Hoffman and Parsons 1997; Pearce 2007).

Ceremonies and stories of Indigenous Americans emphasize the changeable and unpredictable nature of the environment. This emphasis underlies the rituals involved in giving thanks to animals and plants before or after taking them for human use (Pierotti 2005, 2011; Pierotti and Wildcat 1999a), as well as ceremonies such as the First Salmon Ceremonies in the Pacific Northwest and the Sun Dance of the Plains Indian tribes (Harrod 2000). Despite numerous references to “keeping things in balance” (e.g., Krech 1999), Indigenous ceremonies and rituals were based on an understanding of non-equilibrium population dynamics, combined with a realization that the natural world was almost never “in balance” in the sense of remaining constant and unchanging.

It is in the best interest of human societies to try to minimize risk when dealing with key food supplies. This is one reason why gathering by women is probably more important than hunting by men in maintaining the basic sustenance of many Indigenous peoples around the world. This also explains why, during the majority of times, little or nothing is wasted during hunting activities (Pierotti 2005, 2010; Tanner 1979). The rituals associated with minimizing waste are therefore codified as “religious or spiritual,” because caring about your prey makes you much more likely not to harm it, and reduce its dependability as a resource (Anderson 1996; Pierotti 2005; Tanner 1979).

It is fairly obvious that Eurasia and America went down quite separate paths with regard to perceptions of both the meaning of community and the natural world as a whole. This emerged from the way these traditions tried to ensure reliable sources of animal protein. Eurasia (and Africa) turned to the domestication of animals, especially social ungulates (cattle, sheep, goats, pigs, and horses). As a result, the Eurasian tradition either failed to develop, or refused to retain, the concept of nonhuman animals as persons, because they devalued the life of their ungulate *chattel* (an old French word derived from the word *cattle*). This also led to the introduction of a wide range of animal-originated pathogenic organisms that jumped from their original ungulate hosts (Diamond 1997; Pierotti 2004, MS). In Europe and Asia domestication of animals probably predated the domestication of plants. Human hunters wandered with herds. In Eurasia the herding ungulates that hunters followed had social behavior that made them susceptible to domestication, that is, they lived in herds with well developed dominance hierarchies and occupied overlapping home ranges rather than territories (Diamond 1997: 197).

Domestication of plants is a different process, and took place in both the Americas and Eurasia. Indigenous Americans lived and worked with corn, beans, and squash (Mt. Pleasant 2001). These plants are referred to as the “Three Sisters” because of the way they interact ecologically. The corn acts as a support pole on which the beans grow. Beans, which are legumes, fix nitrogen in the soil, thus providing nutrition for both corn and squash. The growth form of the squash as a widespread vine, combined with its hairy leaves and stalks, prevents herbivores ranging from insects to deer from getting to the beans and corn. The three species each enhanced each others’ growth (Bruchac 2003; Mann 2005; Mt. Pleasant 2001).

Domestication of plants does not seem to create a lack of respect for nonhumans. This is probably because plants, especially when grown in a polyculture such as the Three Sisters, seem to retain their essential nature as well as their ecological relationships to one another. In contrast, Eurasian morals and ethics evolved to minimize the recognition of relatedness

between humans and other animals. It is difficult to treat those considered to be relatives as chattel, or as moveable property that you control.

The Western tradition was strengthened by the Renaissance of the fourteenth and fifteenth centuries, which emphasized absolute human autonomy (Coates 1998). The seventeenth century scientific revolution exacerbated the situation by “transforming nature from a living organism into a machine—simple, unfeeling, inert matter with no intelligence, soul, or purpose—the new mechanistic philosophy assisted the commodification of nature . . .” The eighteenth century “Enlightenment” stressed that humans were masters of their own destinies, and emphasized the subjugation of nature (Coates 1998). Europeans who emigrated to North America during the seventeenth and eighteenth centuries were disciples of this cultural, philosophical, and intellectual tradition.

Given this tradition, it is not surprising that when Europeans came to North America, they regarded the “wilderness” as threatening and hostile. Even the earliest European explorers regarded America as a land full of uncontrolled and frightening peoples and animals (Martin 1999). Once Europeans learned of the philosophical and spiritual traditions of the Indigenous peoples, they felt compelled to regard these beliefs as “primitive and savage”; after all, these belief systems emphasized ties to nature or the wild that filled Europeans with fear (Martin 1999; Pierotti 2011).

In contrast, the fundamental philosophical principles of Indigenous peoples are based on an understanding of connection and relatedness. These principles combine with their understanding of the unpredictability of the food sources upon which they depend to develop the attitude towards nonhumans as fellow “persons” (Pierotti 2011; Pierotti and Wildcat 1997a,b). According to one scholar, “the native world should be understood as one of multiple communities of sentient beings in a variety of corporeal forms” (Dreyfus 2008: 21).

One important reason for this difference is that Indigenous peoples lack an immigrant experience within their memories; they assume that they are truly Indigenous, that is, born of this land. Native American stories do not deal with the exact time when “historical” events occurred, since many such events happened so long ago that they exist “on the other side of memory” (Marshall 1995; Pierotti and Wildcat 2000). The point is that the exact locality where these events occurred is of paramount importance; this sense of locality is what ties Indigenous peoples to their local community in both the social and ecological sense (Basso 1996).

Indigenous people view these connections as being fluid over time. Any factor that alters a system, including tampering by humans, can cause changes in many unpredictable ways. Each species is constantly fluctuating, both in behavior and numbers, in response to its interactions with many other species, and to physical factors in the environment. An Osage scholar has stated, “The cosmos was in constant motion and consisted of unending, varied cycles of birth, maturity, old age, death and rebirth. These temporal cycles could not be stopped or reversed, for ‘nothing in the cosmos moved backward’” (LaFlesche 1995: 30).

When one species declines or disappears from a local environment, humans may notice its absence. More importantly, other species in the community are even more likely to notice this absence, because it probably alters their behavior or other ecological relationships in some way or another. One possible conclusion of this line of thinking is that Indigenous impressions are also shared by the nonhumans. Indigenous people felt strongly about their involvement in the natural world; at the same time they felt that they were not fundamentally different from any other species of animal (Deloria 1990; LaFlesche 1995; Pierotti and Wildcat 2000). An example of this type of thinking can be seen in the discussions concerning the re-introduction of wolves into Yellowstone National Park. The argument made by wildlife biologists and conservationists of European heritage to justify this action was that

“Of all the species that inhabited Yellowstone when it was first made a park, all but one can still be found living in the park today. The missing species is the gray wolf” (Pierotti 2011). This is not true; human beings were also regular inhabitants. Shoshone, Arapaho and other tribes were an important part of that ecosystem.

Western conservationists do not appear to consider humans as a missing component of the Yellowstone ecosystem because Western thought persists in defining “wilderness” as ecosystems without humans present (Gomez-Pompa and Kaus 1992). In fact it is true of much of Western ecology that its practitioners consider systems where humans are present to be “disturbed,” rather than “natural.” Indigenous peoples are regularly removed from areas designated as national parks, forest reserves, wildlife areas, and so on. (Dowie 2005). This is true not only in North America. For example, in South Africa and Namibia, Indigenous peoples, such as the !Kung and Juwasi San (“Bushmen”) were removed from National Parks such as Etosha, which had a profound impact on the behavior and ecology of lions, *Panthera leo*, which inhabited the park and had established a long-term symbiotic relationship with the human inhabitants (Marshall-Thomas 1994). In contrast, in both Nepal and Australia a more enlightened approach, co-management of national parks, has been established, which allows Indigenous peoples to continue to inhabit their traditional homelands (De Lacy and Lawson 1997; Howitt 2001; Stevens 1997).

Indigenous peoples do not think of the nonhuman elements of their community as constituting “nature” or as “wilderness,” but as part of their social environment (Allen 1986; Standing Bear 1978). Adherents to this philosophy also do not think of leaving a “house” to “go into nature,” but instead feel that when they leave their shelter and encounter nonhumans and natural physical features that they are just moving into other parts of their home. “What we call nature is conceived by Native peoples as an extension of biological man, therefore a (Native) never feels ‘surrounded by nature’ . . . walking in the forest . . . is not in nature, but is entirely surrounded by cultural meanings his tradition has given to his external surroundings” (Reichel-Dolmatoff 1996).

In traditional Indigenous communities the importance of the local place in determining traditions, combined with the concept of nature as home rather than as “other” has profound implications for Native conceptions of politics and ethics (Basso 1996). Unlike dominant Western political and ethical paradigms which find knowledge of how human beings ought to act imbedded in the life of one’s social, that is, human, relationships, Indigenous peoples find within their concept of community instructions concerning how a person should behave as a member of a community consisting of many nonhuman persons (Deloria 1990, 1992, 1999a,b; Druke 1980; Pierotti 2011; Pierotti and Wildcat 1997b, 2000, 2001; Tinker 2004).

The primary focus of creation stories of many tribes placed human beings as among the last creatures who were created and the youngest of the living families. We were given the ability to do many things but not specific wisdom about the world. So our job was to learn from other beings and to pattern ourselves after their behavior. We were to gather knowledge, not disperse it.

Deloria 1999b, p 224

THE CONCEPT OF PERSONHOOD

In contrast to the ideas just described, Western attitudes generally follow the lead of Aristotle, who defined politics and ethics as exclusively human realms. Thus values, ethics, and politics exclude all entities but other human beings (Pierotti and Wildcat

2000). Therefore, respect and concern for their good are not owed to nonhumans and landforms. By Indigenous standards Aristotle's notion of community membership was overly limited because in Indigenous communities politics and ethics are not limited only to human beings (Allen 1986; Deloria 1990; Martin 1978; Salmon 2000).

The inclusion of other living beings and natural objects into the category of "persons," which includes human beings, requires the development of concepts of politics and ethics that incorporate these other community members (Martin 1999; Pierotti and Wildcat 2000). The line between human and animals (and plants) is so lightly drawn in American Indian cultures that it ceases to exist at certain points (Bruchac 2003; Taylor 1986). Throughout Native American cultures, there is a broad commonality of beliefs about animals in which human and nonhuman are bonded closely and are part of one community involved with one another in terms of empowerment and emotional interactions (Anderson 1996; Barsh 2000; Deloria 1990; Martin 1999; Martinez 1994).

Such beliefs lead to what has been described as "kincentric" ecology, in which humans and nonhumans are viewed as part of an ecological assemblage that is treated as an extended family sharing ancestry and origins (Salmón 2000). Laguna Pueblo people could not have survived in the arid Southwestern U.S. without their recognition that they were "sisters and brothers to badger, antelope, clay, yucca, and sun" (Silko 1996). To Northwest Coast peoples, "Fish, bears, wolves, and eagles were part of the kinship system, part of the community, part of the family structure. Modern urbanite ecologists see these as Other, and romanticize them, but for a Northwest Coast Indian, an alien human was more Other than a local octopus or wolf" (Anderson 1996). The Raramuri (Tarahumara) people of northern Mexico use the term *iwigara* to indicate the way in which they are bound to the land, animals, and winds of their Sierra Madre home. *Iwigara* indicates the interconnectedness and integration of all life in the Sierra Madres, both physical and spiritual (Salmón 2000).

Another illustration is clan names and totems, which reflect the existence of covenants between certain human families and specific animals (Deloria 1990; Pierotti and Wildcat 1997a). *Totem* is derived from the Anishinaabe word *ototeman*, which translates roughly as "my relative" (Bruchac 2003: 160). These nonhumans are connected to families over prolonged periods of time, and offer their assistance and guidance during each generation of humans (Martin 1999; Pierotti and Wildcat 2000). If you have a certain creature as a totem you are not allowed to hunt or kill it (Bruchac 2003), which may explain why in some cultures, for example, the Pacific Northwest, only predatory species are used as clan signifiers (Pierotti 2011). The relationships implied by clan membership have implications that might make adherents to the dominant culture uneasy or uncomfortable. To be a member of Eagle, Wolf, Bear, Deer, or Wasp clan means that you are kin to these other persons; they are your relatives. Ecological connectedness is culturally and ceremonially acknowledged through clan names, totems, and ceremonies (Martin 1999; Pierotti and Wildcat 1997a, 1999b). In Native American stories it is established that animal- and plant-persons existed before human-persons (Deloria 1999b; Pierotti and Wildcat 1997a). Thus, these kin exist as elders and, much as do human elders, they function as teachers and respected members of the community (see the quote from Deloria 1999b above).

In Indigenous traditions, humans typically live in mutual-aid relationships with nonhumans (Barsh 2000). If humans eat or otherwise use nonhumans, they are empowered by that relationship, which leads to mutual respect. Many nonhumans have powers far beyond the capabilities of ordinary humans, and are able to move with ease through worlds impassable to humans (Anderson 1996). Birds move through the air, which is off limits to most humans, and fish and marine mammals move through water in a manner that humans can only imitate in a clumsy fashion.

One logical assumption following from such understanding is that if nonhumans are “persons,” they also can have cognitive abilities, which would mean that they should recognize the danger of being hunted. Thus if a nonhuman was caught, it was assumed to involve some element of choice on their part (Anderson 1996). This led to the concept of the prey “giving itself to you.” This presumed gift required gratitude (thanks), as well as respectful treatment of the body of the nonhuman on the part of the human taking its life (Martin 1999; Pierotti and Wildcat 1999a; Tanner 1979).

Although the prey may not truly give up its life voluntarily, this assumption is an important guiding principle of the rituals that ensured that hunters and fishers treated their take with respect, so as not to offend the prey, in order to ensure that the prey would not abandon them (Pierotti and Wildcat 1999a). “If we do not show respect to the bear when we kill him, he will not return” (traditional Mistassini Cree, cited in Bruchac 2003: 155).

ATTITUDES TOWARDS PREDATORS

This last statement illustrates a major difference between Western and Indigenous ways of understanding the natural world, that is, their attitudes towards and response to predatory organisms, such as wolves, bears, big cats, crocodilians, and sharks. In essence this can be summed up by the observation that, despite their tendency to consume large quantities of animal protein, followers of the Western philosophical tradition tend to regard themselves as prey. As a consequence, individuals who follow this tradition seem to fear and often try to exterminate any potential predator of which they are aware. In contrast, followers of Indigenous philosophical traditions tend to regard themselves as predators and show respect for the nonhumans who share their ecological role (Pierotti 2011; Pierotti and Wildcat 1997b; Schlesier 1987).

To anyone who doubts that this characterization of humans as prey is a crucial aspect of Western understanding, including followers of the Western scientific tradition, consider the recent work by one of the most prominent investigators of the behavior of predatory mammals, Hans Kruuk, who states, “I will start at the *darkest, most horrifying and negative* side of our relationship with (carnivores), that is their predation on us. They can be very *dangerous enemies*” (Kruuk 2002: 55; emphasis added).

This Western perception seems to emerge from the Christian tradition; with Jesus Christ being identified as “the lamb of God.” Thus, the “savior of mankind” is regarded as a prey organism to be sacrificed. It is telling that the individual upon whom much of the moral foundation of contemporary Western society is based is perceived as equivalent to a prey organism, which also leads to the view of his disciples and followers as helpless creatures. Christian symbolism is full of shepherd, sheep, and flock metaphors, for example, the Good Shepherd, reference to a Christian congregation as a “flock,” sinners as “lost lambs or sheep,” and so on. This metaphor can also be seen in the Hebraic tradition in the willingness of Abraham to sacrifice his son, Isaac, and when he decides not to do this, substituting a lamb. Christians are also told how early adherents to their faith were “fed to the lions” by the Romans (Pierotti 2011).

One result of this tendency to identify with prey is that the relationship between Europeans and wolves is best described as a campaign of unimaginable viciousness directed at wolves by Europeans and their descendants (Coleman 2004; McIntyre 1995). This is in direct contrast to Indigenous attitudes that recognize how much nonhuman predators are like humans in their behavior and attitudes. The Cheyenne and Blackfeet developed their creation stories around wolves who served as their guides and instructors. Animals that acted as

hunters were in turn emulated by the human hunters (LaFlesche 1995: 132; Marshall 1995; McClintock 1910; Schleidt 1998; Schlesier 1987: 82). Cheyenne hunters would call wolves to their kill, or set part of the meat aside for wolves, because there are stories about how people in an earlier time fed themselves from kills made by wolves during a time of great hardship (Schlesier 1987).

Prior to the arrival of Europeans, in North America humans and wolves enjoyed a relatively benign relationship between the two species (see also Marshall 1995; Schlesier 1987). There are stories of Numic hunters finding wolf dens and stopping to play with the pups, while the parent wolves observed from a short distance (Wallace and Hoebel 1948). In Shoshone, the name for gray wolf is Numuna (Ramsey 1977: 231), which is similar to the name some Numic peoples use for themselves, for example, Nuhmuhnuh (Comanche Language and Cultural Preservation Committee 2003). Lakota people tell of wolves that encountered a bison killed by humans; after sniffing the arrows, they looked at the humans then walked away (Marshall 1995: 12).

Identification with predators makes Indigenous people feel confident and that they have control over their environment; after all, they are the close relatives and cultural descendants of the most powerful entities in this ecosystem (Barsh 2000, MS; McClintock 1910; Marshall 1995; Martin 2000; Pierotti and Wildcat 1997b, 2000; Tanner 1979).

As Indigenous peoples evolved culturally and ecologically, their survival both as individuals and as cultures depended on their ability to take the lives of other beings. To be an effective hunter required observation of both predators and prey, each of which had at least one ability or characteristic that set it apart from other species and enhanced their chances of survival as individuals (Barsh 2000; Marshall 1995; Nerburn 1994). Humans lacked horns, teeth, claws, and the speed and strength of many other species. Instead they had understanding and language, which allowed them to pass knowledge directly from one generation to the next. "American Indians view reality from the perspective of the one species that has the capability to reflect on the meaning of things" (Deloria 1999b: 130). These peoples survived and prospered by paying careful attention, learning about the strengths and weaknesses of the other organisms in their community, and developing rituals and traditions related to this knowledge that symbolized the importance of the taking of nonhuman lives.

The essence of Native attitudes towards other life forms is "kinship relations in which no element of life can go unattached from human society," which manifests itself in "kinship cycles of responsibility that exist between our species and other species" (Deloria 1999b: 131). "Every species finds meaning in this larger scheme of things and that is why other species are willing to feed and clothe (humans)" (Deloria 1999b, p 149). If nonhumans were understood to have "characteristics similar or equivalent to those of humans, how were humans to understand what it meant to kill animals and consume their flesh?" (Harrod 2000: 46). An Inupiat hunter has stated that,

The greatest peril of life lies in the fact that human food consists entirely of souls. All the creatures we have to kill and eat, all those that we strike down and destroy to make clothes for ourselves, have souls, like we have, that do not perish with the body, and which must therefore be propitiated lest they should revenge themselves on us for taking their bodies.

Ivaluardjuk, cited in Rasmussen 1929

Combined with the unpredictability of environmental conditions, this moral dilemma is a defining element of Native American religious thought. Many rituals and traditions stem from practices developed specifically to provide an ethically satisfying resolution to the taking of other lives, and many contemporary religious practices of Indian people stem from rituals originally developed for hunting, for example, pipe ceremonies and the sweat

lodge, that have been transformed into practices that address the spiritual needs of contemporary Indians (Harrod 2000; Pierotti 2011).

Wolves, cougars, bears, and others were fellow hunters from whom much could be learned. One important aspect of including nonhumans as community members is that it allowed Native Americans to identify with and respect predators, since they knew how difficult it is to take the lives of other individuals (Brightman, 1993; Harrod 2000; Marshall 1995; Marshall-Thomas 1994; Tanner 1979). In this intellectual and spiritual tradition, predation is recognized as an activity that does not involve hostile intent.

Given this heritage, the reliance of plains tribes on wolves as models is not surprising. The weapons of wolves were “formidable, but the first people saw that they were of little use without endurance, patience and perseverance . . . qualities the first peoples could develop in themselves” (Marshall 1995). These peoples felt their connection to wolves was strong because wolves had even instructed them in methods of hunting (Barsh MS; Schlesier 1987). Wolves were respected for their alertness, endurance, and their ability to be part of a close-knit group, but also to function well when they were alone (LaFlesche 2005: 132). Leaders of war parties were “spoken of as wolves, because they are men of great fortitude . . . who, like wolves, are ever alert, active and tireless . . . who can resist the pangs of hunger and the craving for sleep . . .” (LaFlesche 2005: 132). Most important, however, was that if people were to emulate the wolf, like the wolf, they also had to exist to serve their own social community and the local ecological community (Marshall 1995).

These cooperative, even “friendly” relationships between species serve as spiritual acknowledgement of the realization that no single organism can exist without the connections it shares with many other organisms. Eating parts of other organisms demonstrates empirically that they are made of the same materials of which you are made (Pierotti and Wildcat 1997b, 2000, 2001). Christianity employs a similar principle in its communion rituals as a way of establishing links between their “savior” and contemporary humans.

Recognizing connectedness did not mean, however, that animals or plants should not be taken or used for food or clothing (Taylor 1986, 1992). This recognition led to ethical and spiritual conclusions based on the concept of respect: (a) lives of other organisms should not be taken frivolously, and (b) other life forms exist on their own terms, and were not put here only for human use (Pierotti and Wildcat 2000, 2001). By giving up its life the animal makes a profound sacrifice, which requires acknowledgement and gratitude (cf. Marshall-Thomas 1994).

Indigenous people experienced other creatures in their roles as parents, as offspring, and ultimately as persons within a shared community. One indication of this mutuality was that it was always possible that the nonhumans upon whom the human culture depended could go away. Realizing this provides an explanation for First Salmon ceremonies, the prayers and thanks to deer and bison, and the treatment of bear and wolf as honored teachers who helped humans figure out how to feed and care for themselves (Pierotti 2011).

THE NATURE OF CREATORS

In Indigenous belief systems, creators or transformers are typically nonhuman entities, who are almost always represented by a nonhuman species that is considered important to the local ecological community (Pierotti 2011; Pierotti and Wildcat 1997a), which reinforces relatedness and connectedness. Significant nonhuman species are considered to be the originators of cultural traditions and sometimes of human beings themselves. This is exemplified by the treatment of Raven as the creator figure in cultural traditions of the Pacific Northwest

and Alaska (Anderson 1996; Nelson 1983) and by the treatment of Wolf and Coyote as creator and trickster figures respectively in the Plains and the Intermountain West (Bright 1993; Buller 1983; Harrod 2000; Marshall 1995).

This employment of nonhumans as creator figures for human cultural and spiritual traditions raises an important philosophical question, that is, “How does it change the worldview of a people if the entity that is given responsibility for creating their culture is not a human, or even humanlike?” Not only is the creator nonhuman, but part of the ecological community.

One consequence of viewing your creator as a nonhuman (animal or plant) is that it seems very unlikely that humans living under such cultural traditions would be troubled by the idea that humans, including themselves, came from organisms that would not be recognized as human and that existed before human-persons (Pierotti 2011; Pierotti and Wildcat 1997a). This is an important point in the current debate over evolution, where one major issue is whether humans should be considered as having come from organisms that are not human, or alternatively if they were specially created in the image of an anthropomorphic creator figure, such as the Christian God.

If the entity you consider to be your creator represents a species of animal or plant that you are likely to encounter in your immediate environment and during your daily activities, this functions to maintain respect and affection for individuals of this species, as well as for the natural world and its other inhabitants. In addition, this means that the creator is internal to the system standing in opposition to Western concepts, which assume that the creator is external to the system. This in turn reinforces the idea of connectedness, through acknowledgment of a member of the ecological community as the originator of the local cultural tradition (Pierotti 2011).

To function as a creator it is necessary to exist prior to your creation. Thus, it is clear that Indigenous Americans were aware that other nonhuman species existed in the world before humans did. In Rock Cree cosmogony, animals were recognized to have existed before human beings, and humans were known to come from animals during the regression of the earth (Brightman 1993). In the Lakota tradition it is recognized that “Sugmanitu Tanka Oyate (wolves) were a nation long before human beings realized and declared themselves a nation” (Manuel Iron Cloud, cited in McIntyre 1995).

The Western monotheistic religious tradition posits a creator that is human in both form and thought. This creator, or god, is typically assumed to have human limitations and human values, but exists external to the system, which it created. Many followers of the Western philosophical tradition assume that if God does not think like them, then he cannot think at all, and therefore does not exist (Davies 1994: 77–78). This conundrum reveals the limits of the Western philosophical tradition, and why fundamentalist Christians have resorted to the idea of “intelligent design,” which seems to assume that the creator functions as a master engineer (Petto and Godfrey 2007). As a thought exercise, imagine a creator that is not human or even remotely human-like in its thought patterns. This entity would not see humans as superior to or above other life forms because all life forms are its children. In this worldview, the world undergoes many changes but the creator, which is part of the system, experiences these changes. During times of major environmental change some life forms may become extinct, while others survive even through extreme changes in environmental conditions. The life forms that persist, either as individuals or populations, are not “favored” or “chosen,” they are simply the organisms able to survive and reproduce in the changed environment (Carroll 2006; Gould 2002; Kirschner and Gerhart 2005). Those that do not persist return to the earth and their components will reappear as part of new forms of life. Thus, it is environmental change that helps to “shape” the life forms to come, so these

changes can be described as drivers of the process of “creation.” This way of viewing the world is entirely consistent with Indigenous stories and ceremonies, which acknowledge the existence of a changeable world, in which those changes are often unpredictable (Pierotti 2011).

Humans are included among the life forms that suffer the consequences of changing environmental conditions. As an example of how an Indigenous perspective views the functioning of and relationships between the creator and life forms (including humans) within ecosystems, let us examine the 1911 statement of Okute (Shooter), a Teton Lakota.

Animals and plants are taught by Wakan Tanka (the Lakota creative force) what they are to do. Wakan Tanka teaches the birds to make nests, yet the nests of all birds are not alike. Wakan Tanka gives them merely the outline. Some make better nests than others. . . . Some animals also take better care of their young than others. . . . All birds, even those of the same species, are not alike, and it is the same with animals, and with human beings. The reason Wakan Tanka does not make two birds, or animals, or human beings exactly alike is because each is placed here to be an independent individual and to rely upon itself. . . . From my boyhood I have observed leaves, trees, and grass, and I have never found two alike. They may have a general likeness, but on examination I have found that they differ slightly. It is the same with animals. . . . It is the same with human beings, there is some *place which is best adapted to each* . . . *An animal depends upon the natural conditions around it.* If the buffalo were here today, I think they would be very different from the buffalo of the old days because all the natural conditions have changed. They would not find the same food, nor the same surroundings. . . . We see the same change in our ponies . . . It is the same with the Indians. . . .

McLuhan 1971: 18–19; emphasis added

To a person familiar with ecological principles this statement by Okute is a concise summary of individual variation and microevolution resulting from environmental changes. Indigenous cultures were aware that the world changed and that often when it did, some species, or even human cultures, were unable to persist or thrive. A powerful example of this attitude can be seen in this story of an exchange between human and nonhuman from Anishinaabeg writer Louise Erdrich:

I spoke to the wolf, asking my own question: “Wolf” I said, “Your people are hunted from the air and poisoned on the ground and killed on sight . . . and stuffed in cages and almost wiped out. How is it that you going on living with such sorrow? How do you go on without turning around and destroying yourselves, as so many of us Anishinaabeg have done under similar circumstances?”

And the wolf answered, not in words, but with a continuation of his stare. “We live because we live.” He did not ask questions. He did not give reasons. And I understood him then. Wolves accept the life they are given. They do not look around them and wish for a different life, or shorten their lives resenting the humans, or even fear them any more than is appropriate. They are efficient. They deal with what they encounter and then go on. Minute by minute. One day to the next.

Erdrich 2005: 120–121

Many Indigenous cultures survived and a few have even thrived, but one major change in the environment may have been particularly destructive. The impact of contagious diseases introduced to the Americas as part of the European invasions apparently led many Indigenous people to feel as if the world had turned against them (Martin 1978; Pierotti 2004). This social and demographic devastation was probably enhanced by the apparent success of Europeans, because they did not suffer as much from the diseases they had brought with them. This combination of factors may have led many Indigenous people to abandon their own spiritual traditions and accept European religions and spiritual traditions.

The word “creation” can be used to refer to various events, including the origins of life itself, which probably happened several times (Barton et al. 2007). The term can also be employed to refer to the origins of new forms of life in response to environmental changes (Gould 2002). With regard to the origin of life, and of the universe, we will never have unquestionable proof of what took place. Evidence can be gathered to support one perspective or another, but absolute proof will probably always be lacking, which is why the origin of life is not really an evolutionary question (Pierotti 2011). The key point on the origin of life is that regardless of exactly how it happened, it took place billions of years ago. Since modern humans did not exist until the last few hundred thousand years, whatever the creative force was at the beginning of life it certainly was not human. In consequence, I look to the one entity that I can be sure was in existence at that time, the Earth itself. To me the Earth, with all of its changeable faces and moods, serves as the most obvious creator imaginable; one that should be acceptable to all peoples and cultural traditions.

REFERENCES

- ALLEN PG. *The sacred hoop: recovering the feminine in American Indian traditions*. Boston (MA): Beacon Press; 1986.
- ANDERSON EN. *Ecologies of the heart: emotion, belief, and the environment*. New York: Oxford University Press; 1996.
- BAIN K. *What the best college teachers do*. Cambridge (MA): Harvard University Press; 2004.
- BARSH RL. Forests, indigenous peoples, and biodiversity. *Glob Biodivers (Can Mus Nat)* 1997;7(2):20–24.
- BARSH RL. Taking indigenous science seriously. In: BOCKING SA, editor. *Biodiversity in Canada: ecology, ideas, and action*. Toronto (ON): Broadview Press; 2000. p 152–173.
- BARSH RL. *Nonagricultural peoples and captive wildlife: implications for ecology and evolution*. Unpublished MS.
- BARTON NH, BRIGGS DEG, EISEN JA, GOLDSTEIN DB, PATEL NH. *Evolution*. New York: Cold Spring Harbor Laboratory Press; 2007.
- BASSO K. *Wisdom sits in places*. Albuquerque: University of New Mexico Press; 1996.
- BOTKIN D. *Discordant harmonies: a new ecology for the twenty-first century*. New York: Oxford University Press; 1990.
- BOTKIN D. *A new balance of nature*. *Wilson Quart* 1991; Spring:61–72.
- BRIGHT W. *A coyote reader*. Berkeley: University of California Press; 1993.
- BRIGHTMAN R. *Grateful prey: Rock Cree human–animal relationships*. Berkeley: University of California Press; 1993.
- BRUCHAC J. *Our stories remembered: American Indian history, culture, and values through storytelling*. Golden (CO): Fulcrum Press; 2003.
- BULLER G. *Comanche and coyote, the culture maker*. In: SWANN B, editor. *Smoothing the ground*. Berkeley: University of California Press; 1983. p 245–258.
- CARROLL SB. *The making of the fittest: DNA and the ultimate forensic record of evolution*. New York: W.W. Norton; 2006.
- COATES P. *Nature: Western attitudes since ancient times*. Berkeley: University of California Press. 1998.
- COLEMAN JT. *Vicious: wolves and men in America*. New Haven (CT): Yale University Press; 2004.
- DARWIN C. *The origin of species by means of natural selection*. London (UK): Studio Editions; 1859.
- DAVIES R. *The cunning man*. Toronto (ON): McLelland and Stewart; 1994.
- DE LACY T, LAWSON B. *The Uluru-Kakadu Model: joint management of aboriginal owned national parks in Australia*. In: STEVENS S, editor. *Conservation through cultural survival: indigenous peoples and protected areas*. Washington (DC): Island Press; 1997. p 155–187.
- DELORIA V, JR. *Knowing and understanding: traditional education in the modern world*. *Winds Change* 1990; 5(1):12–18.
- DELORIA V, JR. *The spatial problem of history*. In: *God is red*. Golden (CO): North American Press; 1992. p 114–134.
- DELORIA V, JR. *For this land: writings on religion in America*. New York: Routledge Press; 1999a.
- DELORIA V, JR. *Kinship with the world*. In: *Spirit and Reason: The Vine Deloria Jr. Reader*. Golden (CO): Fulcrum Press; 1999b.
- DIAMOND J. *Guns, Germs, and Steel: The Fates of Human Societies*. New York: W. W. Norton; 1997.
- DOWIE M. *Conservation refugees*. *Orion* 2005;24(6):16–27.
- DREYFUS PJ. *Our better nature: environment and the making of San Francisco*. Norman: University of Oklahoma Press; 2008.
- DRUKE MA. *The concept of personhood in 17th and 18th century Iroquois ethnoperpersonality*. In: *Studies in Iroquois Culture. Papers in Northeastern Anthropology* 6. George’s Mill (NH): Man in the Northeast. 1980. p 59–69.
- ERDRICH L. *The painted drum*. New York: Harper Collins; 2005.
- GOMEZ-POMPA A, KAUS A. *Taming the wilderness myth*. *BioScience* 1992;42:271–279.
- GOULD SJ. *The structure of evolutionary theory*. Cambridge (MA): Belknap Press of Harvard University Press; 2002.

- HARNEY C. *The way it is: one water . . . one air . . . one Mother Earth*. Nevada City (CA): Blue Dolphin Publishing; 1995.
- HARROD HI. *The animals came dancing: Native American sacred ecology and animal kinship*. Tucson: University of Arizona Press; 2000.
- HESSE M. *The structure of scientific inference*. Berkeley: University of California Press; 1974.
- HOFFMAN AA, PARSONS PA. *Extreme environmental change and evolution*. New York: Cambridge University Press; 1997.
- HOWITT R. *Rethinking resource management: justice, sustainability, and indigenous peoples*. New York: Routledge Press; 2001.
- KIDWELL CS, VELIE A. *Native American Studies*. Lincoln, NE: University of Nebraska Press; 2005.
- KIRSCHNER MW, GERHART JC. *The plausibility of life: resolving Darwin's dilemma*. New Haven (CT): Yale University Press; 2005.
- KRECH S. III. *The Ecological Indian: Myth and History*. New York: W. W. Norton; 1999.
- KRUUK H. *Hunter and hunted: relationships between carnivores and people*. Cambridge (UK): Cambridge University Press; 2002.
- LAFLASCHE F. *The Osage and the invisible world. Civilization of the American Indian 217*. Norman: University of Oklahoma Press; 1995.
- LEWONTIN R. *The triple helix: gene, organism, and environment*. Cambridge (MA): Harvard University Press; 2001.
- MANN CC. *1491: New revelations of America before Columbus*. New York: Knopf; 2005.
- MARSHALL J III. *On behalf of the wolf and the First Peoples. Santa Fe (NM): Red Crane Books; 1995.*
- MARSHALL J III. *The Lakota way*. New York: Viking Compass Books; 2001.
- MARSHALL-THOMAS E. *The tribe of tiger: cats and their culture*. New York: Simon and Schuster; 1994.
- MARTIN CL. *Keepers of the game: Indian-animal relationships and the fur trade*. Berkeley: University of California Press; 1978.
- MARTIN CL. *The way of the human being*. New Haven (CT): Yale University Press; 1999.
- MARTIN JW. *The land looks after us: a history of Native American religion*. New York: Oxford University Press; 2000.
- MARTINEZ D. *Traditional environmental knowledge connects land and culture*. *Winds Change* 1994;9(4):89–94.
- MCCLINTOCK W. *The Old North Trail; or life, legends, and religion of the Blackfeet Indians*. London: MacMillan Press; 1910.
- MCINTYRE R. *War against the wolf: America's campaign to exterminate the wolf*. Stillwater (MN): Voyageur Press; 1995.
- MC LUHAN TC. *Touch the earth: a self-portrait of Indian existence*. New York: Promontory Press; 1971.
- MONOD J. *Chance and necessity*. London: Collins; 1979.
- NELSON R. *Make Prayers to the Raven*. Chicago: University of Chicago Press; 1983.
- PLEASANT Mt. J. *The Three Sisters care for the land and the people*. In: JAMES K, editor. *Science and native American communities. Legacies of pain, visions of promise*. Lincoln: University of Nebraska Press; 2001. Chapter 9.
- NERBURN K. *Neither wolf nor dog: on forgotten roads with an Indian elder*. Novato (CA): New World Library; 1994.
- PAGELS E. *The origin of Satan*. New York: Vintage Books, Random House; 1995.
- PAPANIKOLAS Z. *Trickster in the land of dreams*. Lincoln: Bison Books, University of Nebraska Press; 1995.
- PAVLIK S. *American Indian spirituality, traditional knowledge, and the "Demon-haunted" world of Western science*. *Am Ind Cult Res J* 1997;21:281–293.
- PEARCE F. *With speed and violence: why scientists fear tipping points in climate change*. Boston (MA): Beacon Press; 2007.
- PETTO AJ, GODFREY LR. *Scientists confront intelligent design and creationism*. New York: W.W. Norton; 2007.
- PIEROTTI R. *Animal diseases as environmental factors*. In: KRECH S, MERCHANT C, editors. *Encyclopedia of world environmental history*. New York: Berkshire Publishing; 2004. p 313–316.
- PIEROTTI R. *Hunting, religious restrictions and implications*. In: *Encyclopedia of Native American religious practices*. Broomfield (CO): ABC CLIO Press; 2005. p 391–400.
- PIEROTTI R. *Indigenous knowledge, ecology and evolutionary biology*. New York and London: Routledge, Taylor and Francis Group; 2011.
- PIEROTTI R, WILDCAT D. *Evolution, creation, and native traditions*. *Winds Change* 1997a;12(2):73–77.
- PIEROTTI R, WILDCAT D. *The science of ecology and Native American traditions*. *Winds Change* 1997b;12(4): 94–98.
- PIEROTTI R, WILDCAT D. *Connectedness of predators and prey: Native Americans and fisheries management*. *Fisheries* 1999a;24(4):22–23.
- PIEROTTI R, WILDCAT D. *Traditional knowledge, culturally based worldviews and Western science*. In: POSEY D, editor. *Cultural and spiritual values of biodiversity*. London: UN Environment Program Intermediate Technology Publication; 1999b. p 192–199.
- PIEROTTI R, WILDCAT D. *Traditional ecological knowledge: the third alternative*. *Ecol Appl* 2000;10:1333–1340.
- PIEROTTI R, WILDCAT D. *Being native to this place. In American Indians in History, 1870–2000*. Sterling Evans, ed. Westport, CT: Greenwood Publishing; 2001.
- RAMSEY J. *Coyote was going there: Indian literature of the Oregon Country*. Seattle: University of Washington Press; 1977.
- RASMUSSEN K. *The intellectual culture of the Iglulik Eskimos*. Vol. 7 of *Report of the Fifth Thule Expedition, 1921–1924*. Copenhagen: Gyldendalske Boghandel; 1929.
- REICHEL-DOLMATOFF G. *The forest within: the worldview of the Tukano Amazonian Indians*. Tulsa (OK): Council Oak Books; 1996.

- SAGAN C. The demon-haunted world: science as a candle in the dark. New York: Random House; 1995.
- SALMON E. Kincentric ecology: indigenous perceptions of the human–nature relationship. *Ecol Appl* 2000;10: 1327.
- SCHLEIDT WM. Is humaneness canine? *Hum Ethol Bull* 1998;13(4):3–4.
- SCHLESIER KH. The wolves of heaven: Cheyenne shamanism, ceremonies, and prehistoric origins. *Civilization of the American Indian series 183*. Norman: University of Oklahoma Press; 1987.
- SILKO LM. *Yellow woman and a beauty of the spirit*. New York: Simon and Shuster; 1996.
- SMITH AM. *Shoshone Tales*. Salt Lake City: University of Utah Press; 1993.
- STANDING BEAR L. *Land of the Spotted Eagle*. Lincoln: University of Nebraska Press; 1978.
- STEVENS S, editor. *Conservation through cultural survival: indigenous peoples and protected areas*. Washington (DC): Island Press; 1997.
- TANNER A. *Bringing home animals*. London: C. Hurst; 1979.
- TAYLOR PW. *Respect for nature*. Princeton (NJ): Princeton University Press; 1986.
- TAYLOR PW. The ethics of respect for nature. In: HARGROVE EC, editor. *The animal rights/environmental ethics debate: the environmental perspective*. Albany (NY): State University of New York Press; 1992. p 95–120.
- TINKER G. The stones shall cry out: consciousness, rocks, and Indians. *Wicazo Sa Rev* 2004;105–125.
- TURNER N. *The earth's blanket: traditional teachings for sustainable living*. Seattle: University of Washington Press; 2005.
- WALLACE E, HOEBEL EA. *Comanches: lords of the Southern Plains*. Norman: University of Oklahoma Press; 1948.

Chapter 6

Ethnozoology

EUGENE S. HUNN

University of Washington, Seattle, WA

DEFINITION OF TERMS AND SCOPE OF THE FIELD	83
A BRIEF HISTORY OF ETHNOZOOLOGICAL INVESTIGATIONS	84
CASE STUDIES AND THEORETICAL ISSUES	85
FOLK BIOLOGICAL CLASSIFICATION AND NOMENCLATURE	85
GENERAL PRINCIPLES OF CLASSIFICATION AND NOMENCLATURE	86
“THE HUNTING HYPOTHESIS” VERSUS “WOMAN THE GATHERER”	87
THE DIETARY ROLE OF MEAT IN FARMING SOCIETIES	88
THE ROLE OF ANIMALS AMONG PASTORALISTS	89
CONSERVATION	90
ANIMALS ARE “GOOD TO THINK”	92
ANIMISM	93
REFERENCES	94

DEFINITION OF TERMS AND SCOPE OF THE FIELD

Ethnozoology may be defined as the study of local knowledge of fauna, and the culturally mediated relationships between communities of people and the other animals of their environment. Local knowledge begins with animal nomenclature and classification in the local idiom. That is the foundation for local knowledge of the behavior and ecology of fauna and the application of that knowledge in people’s interactions with animals, domestic and wild. Cultural relationships include symbolic and spiritual connections demonstrated in myth, ritual, art, and philosophical speculation. I would stress *relationships* of human communities with their local faunas, mediated by cultural understandings. This avoids the suggestion that “cultures” are the responsible agents. Ethnozoology includes, for example, ethnoornithology, ethnoichthyology, ethnoentomology, and ethnomalacology (Meehan 1982). R.E. Johannes’s *Words of the Lagoon* (1981)—a sensitive account of local

fishermen's knowledge of the life of Palauan reefs, lagoons, and adjacent seas—was informed by the author's professional interest in tropical marine ecology. Ethnoentomological studies have been dominated by studies of edible insects (Ruddle 1973).

Principles of classification and nomenclature apply generally to living kinds, though onomatopoeia is particularly prominent in the names of birds and frogs. Some ecological issues contrast ethnozoology and ethnobotany. Hunting has long been an obsession of theorists of human evolution. William Laughlin characterized hunting as the “integrating bio-behavior system” defining the human evolutionary path (1968). However, this ignored the economic contributions of “woman the gatherer” (Dahlberg 1975). The relative dietary contributions of plant versus animal foods under various subsistence regimes remains a critically important issue with respect to our understanding of human nature and of the evolving human ecological role.

Animals of all sorts have held a special emotional, symbolic, and spiritual relationship to humans, most likely a consequence of the capacity for complex and rapid movement that most land animals share with humans, suggestive of an internal dynamic of will and intelligence difficult to perceive in plants (or in sedentary animals such as corals). Thus animals play a disproportionately large role in sacred stories, such as the exploits of Coyote and Raven in Native American mythic narrative (Ramsey 1977).

Ethnobotanical studies of medicinal plants far outnumber studies of the medicinal values of animal products. Plants have evolved biochemical defenses against herbivores and attractants to exploit mobile animals for pollination and seed distribution (Johns 1990).

Ethnozoological methodology poses distinct practical problems for collecting and curating voucher specimens. Plants such as palms, cacti, and agaves pose particular problems, but nothing comparable to collecting a voucher specimen of a blue whale, polar bear, or ostrich. In lieu of such efforts, ethnozoologists may make do with photographs, sound recordings (for birds and amphibians, see Hunn 1992), or skeletal material from hunters' caches. Entomological vouchers require nets, killing bottles, pins, boxes for hard-bodied specimens, and vials of alcohol for soft-bodied species. It may prove particularly difficult to find reliable repositories for such specimens and taxonomists willing and able to determine the scientific identities of one's invertebrate samples. Nevertheless, without some means of securely documenting the scientific identity of the referents of local names, an ethnozoological investigation will remain of strictly limited significance.

A BRIEF HISTORY OF ETHNOZOOLOGICAL INVESTIGATIONS

The term “ethnozoology” first appeared in print in a note entitled “Aboriginal American zoötechny” by Otis Mason (1899). Mason defined the field as “zoology of the region as recounted by the savage” (1899: 50). This invidious distinction between “savages” and modern civilized folk is a recurrent theme in definitions not only of ethnozoology but of ethnobotany and ethnobiology more generally (Castetter 1978; Clément 1998; Nolan and Turner, this volume). “Savage” and “primitive”, being inaccurate, are replaced now by “Indigenous”, “traditional”, “subsistence-based”, or “local” to describe the societies in question. Moreover, immigrant and urban communities too have their ethnozoologies.

Scholarly interest in what we now define as ethnozoology dates to antiquity. Herodotus wrote:

The cats on their decease are taken to the city of Bubastis, where they are embalmed, after which they are buried in certain sacred repositories. The dogs are interred in the cities to which they belong, also in sacred burial-places. The same practice obtains with respect to the ichneumons

[a kind of civet]; the hawks and shrew-mice, on the contrary, are conveyed to the city of Buto for burial, and the ibises to Hermopolis. . . . (Rawlinson 1928: 104)

The first comprehensive ethnozoological ethnography is that of the Tewa of New Mexico (Henderson and Harrington 1914), a surprisingly modern treatment. Wyman and Bailey's *Navajo Indian Ethnoentomology* (1964) is a model application of ethnobiological methods. R.N.H. Bulmer's ethnozoological researches in the Papua New Guinea highlands, particularly in his collaboration with the Kalam scholar Ian Saem Majnep, remains the most sensitive account of a traditional zoological science (Majnep and Bulmer 1977, 2007). Amadeo Rea's "salvage" ethnography of Northern Piman ethnozoology demonstrates how much can be learnt from an apprenticeship with knowledgeable Indian elders combined with meticulous reading and sophisticated interpretation of ethnohistorical, archival, and linguistic sources (Rea 1998, 2007). The present author's Tzeltal Mayan and Zapotec ethnozoological work was inspired by both (Hunn 1977, 2008). What all these efforts have in common is the felicitous combination of a fascination with animals and a deep respect for Indigenous people. A geographic sampler of detailed ethnozoological ethnographies might include Waddy's (1982, 1988) comprehensive ethnobiology of the Groote Eylandt of Australia's Northern Territory, Ellen's (1993a,b) analysis of Nuaulu animal classification on Seram, Indonesia, Forth's (2004) ethno-ornithological studies with the Nage of eastern Indonesia, Griaule's cosmic conversations with the Dogon hunter Ogotemmêli (Griaule 1965, cf. Walter 1991), Descola's (1994) Achuar ethnography, and Anderson's study of Yucatec Mayan farmers (Anderson and Medina Tzuc 2005).

The anthology *Man, Culture, and Animals* edited by Anthony Leeds and Andrew P. Vayda (1965) represents the centrality of ethnozoological concern for students of human ecology. This tradition of investigation continued in studies focused on particular ecological issues, such as controversies over the nature of Indigenous conservation among subsistence hunters and the role of animistic beliefs in hunting practice. Outstanding contributions in this tradition include Tanner's *Bringing Home Animals* (1979), Nelson's *Make Prayers to the Raven* (1983), and Brightman's *Grateful Prey: Rock Cree Human-Animal Relationships* (1973). Analyses of hunting from an evolutionary ecological perspective include Smith's *Inujjuamiut Foraging Strategies* (1991) and Alvard's studies of Amazonian hunting strategies (1995). For a critical evaluation of this approach see Ingold's essay "The optimal forager and economic man" (2000); see also Pierotti, Chapter 5.

CASE STUDIES AND THEORETICAL ISSUES

Folk Biological Classification and Nomenclature

Ethnozoology may contribute to the clarification of a profound philosophical issue: is nature "natural" or a cultural construct? One corollary of a radical cultural-relativist position is that "species" have no objective reality. If this were the case one would not expect substantial agreement with regard to the recognition of species as basic elements of our natural environment across cultures that have no common historical connection. Such a conclusion is false. Diamond (1966) studied the ornithological expertise of the Fore of highland Papua New Guinea. Bulmer (1974), writing of the neighboring Kalam, analyzed the complex symbolism of the cassowary, its mythic partnership with the first humans, and the special hunting and dietary restriction accorded the cassowary as an extraordinary creature. The Kalam and the Fore classify bats as "birds". Diamond's study has since been replicated in a number of

carefully documented systematic ethnozoological studies, though in most cases the degree of 1:1 correspondence of locally named “species” to Western scientific species is somewhat less than the 85% of the Fore. For example, Tenejapa Tzeltal Maya bird species correspond 1:1 in 79% of the cases (Hunn 1977: 81). In every case, however, local community traditions recognize and name “natural kinds” that reproduce “each after its own kind”—in a word, biological species.

Species are abstractions inferred from observations of thousands of individual organisms, each unique yet exhibiting “family resemblances” and interacting with one another in characteristic ways. The Fore recognize two levels of classification in their distinction between “large names” and “small names” such as *iré*, the white-spotted scrub-thrush (*Eupetes leucostictus*), included as a kind of ‘bird’. This distinction seems implicit in the application of binomial names, as in the case of Tenejapa Tzeltal robins (i.e., species of the thrush genus *Turdus*). Here up to five kinds of *toht* may be recognized, e.g., *bats’il toht*, literally ‘real robin’ for the prototypical Rufous-Backed Thrush (*Turdus rufitorques*) of the central highland forests of Chiapas and *k’an toht* ‘yellow robin’ for the Clay-Colored Thrush (*Turdus grayi*), common at lower elevations. All are then construed to be kinds of the life-form *mut* ‘bird’ which in turn is encompassed by *chan-balam*, or ‘animal’ (literally ‘snake-and-jaguar’; Hunn 1977: 180–181). This hierarchy of named categories represents an incipient manifestation of Linnaean taxonomic reasoning. Recognition and naming of natural kinds or species is a human universal. So also is the recognition that diversity of species reflects a hierarchy of degrees of family resemblance (Brown 1979), anticipating the Darwinian understanding of species as the end products of a process of *descent with modification*.

General Principles of Classification and Nomenclature

Tzeltal Maya farmers of Tenejapa, Chiapas, Mexico, recognize 448 kinds of animals, including 230 kinds of invertebrates (Hunn 1977: 81). The number of invertebrate species in their home territory is unknown but would number many thousands. Thus the correspondence between Tzeltal “species” and Linnaean species is far from perfect in the case of invertebrates. We may attribute this to the highly selective attention the Tzeltal Maya pay to invertebrates, due in part to their small size. Yet when their curiosity is aroused they are quite capable of systematic precision worthy of the world’s leading entomologists. Social hymenoptera (ants, bees, and wasps) fascinate the Tenejapa Tzeltal Maya. They recognize 43 kinds of ants, bees, and wasps and in many instances their categories correspond very well to the genera and species of the academic entomologist. Comparison goes beyond the naming of species to the recognition that patterns of behavior may provide the most reliable clues to the identity of species. One of my Tenejapan guides illustrated each type of wasp by drawing the shape and location of their nests (cf. Wilson 1971; Hunn 1977: 267, Fig. 5.197).

People living close to the natural world pay close attention to empirical reality. Ethnozoology shows that such peoples develop understandings beyond what is immediately relevant for survival (Berlin 1992). That is, their knowledge is not strictly utilitarian, however selective it may be. While it is noteworthy that the Tzeltal and Yucatec Maya carefully delineate species of ants, bees, and wasps, they are far less precise in their classification of butterflies and moths, though one might argue that butterflies and moths are an equally conspicuous and diverse element of the local natural environment. Why this contrast? It seems inescapable that ants, bees, and wasps have a far greater practical impact on the everyday lives of Tenejapanecos than do butterflies and moths, suggesting that utilitarianism plays

a role in directing cultural attention to natural diversity (Hunn 1982a). Yet the “practical significance” of ants, bees, and wasps is not a simple matter of filling one’s stomach, as some would have it, but must include considerations of danger posed by poisonous insects, competition from insects capable of defoliating one’s crops, and even the symbolic power of recognizing an affinity with a powerful insect society, as in Darrell Posey’s analysis of Kayapo ethnoentomology (Posey 1981).

A fourth study of the empirical acumen of native peoples is the “ethnoethology”—the knowledge of animal behavior—of the !Kung San hunters of the Kalahari of southern Africa. A professional wildlife biologist, Nicolas Blurton-Jones, and the anthropologist Melvin Konner consulted groups of San hunters at their camps in the Kalahari on the animals they encountered while hunting (Blurton-Jones and Konner 1976). Blurton-Jones posed questions of interest to academic zoologists. Konner translated these queries into the local San language. The hunters’ debates in response were recorded, transcribed, and translated back into English. Blurton-Jones judged the San hunters’ knowledge dependable in most cases, noting a few instances in which the hunters’ opinions were at variance with “scientific fact”, as was known at the time. For example, San hunters agreed that lions were meticulous eaters, rejecting meat that had been spoiled by feces from a ruptured lower intestine. As proof they noted having observed that such contaminated carcasses had been abandoned by the lions. This conclusion was subsequently corroborated by professional biologists.

Blurton-Jones was impressed by the fact that the San freely challenged their fellow hunters, questioning the basis of a judgment at odds with their own experience. In this respect they acted in the best tradition of academic science, carefully evaluating judgments with regard to empirical evidence and the logic of argument. Nor were San hunters slavish positivists. Many of their generalizations about animal behavior rested on inferences from signs such as tracks and spoor rather than direct observation, but such inferences were carefully reasoned. A classic ethnographic film by John Marshall, “The Hunters” (1957), follows four San men as they first chase, then wound, then track, and ultimate kill a giraffe, a hunt lasting three days. Their lethal weapon was a diminutive bow and arrow, the arrow poisoned by a paste elaborately processed from the larvae of a species of beetle found beneath the roots of one particular savannah shrub. To track the giraffe required recognizing the individual tracks of the wounded animal. The hunters were thus able to anticipate its movements, intercept it, and finally subdue it. The animal was butchered as befits a being of great power, with respect mixed with joy in anticipation of the feast soon to be shared.

Blurton-Jones and Konner showed the San to be systematic and skeptical observers of the natural world, scientists in the best tradition of natural history. However, the authors judge the San as lacking in theoretical sophistication, because they appeared to have little interest in such questions as “why” lions or elephants or kudus acted as they did. Rather, the San were satisfied to observe simply that lions act like lions and kudus like kudus, because that is their nature.

“The Hunting Hypothesis” versus “Woman the Gatherer”

Animals play key dietary roles in many human societies, past and present, from Arctic and Kalahari hunters, East African cattle pastoralists, Palauan fisher folk, New Guinea and Hindu farmers, to modern American fast-food fans. Contemporary culinary habits have affected our judgment as to the proper role of meat in human evolution. The orthodox position held that hunting was the evolutionary innovation that set our species apart from our great ape relations. This position was forcefully articulated by William S. Laughlin in his

contribution to the *Man the Hunter* volume, “Hunting: an integrating biobehavior system and its evolutionary importance” (Laughlin 1968), the proceedings of the first of an ongoing series of biennial conferences by students of so-called hunter-gatherer societies. Robert Ardrey, a prolific journalistic popular writer, promoted *The Hunting Hypothesis* (1976), the title of the last of his four books elaborating his reading of the anthropological literature on human evolution. The *hunting hypothesis* proved misleading in several respects, first in suggesting that *man* the hunter was the key player in the evolutionary transition from ape to human. This ignored the economic contributions of women, which have been shown to be on a par with that of men. Richard Lee’s data on the division of labor by sex among the !Kung San of the Kalahari showed clearly that vegetal foods gathered by women—notably the rich mongongo nut (*Schinziophyton* [*Ricinodendron*] *rautanenii* (Schinz) Radcl.-Sm.)—represented well over 50% of both calories and protein in the San diet (Lee 1979: 271). Women were not limited to childbearing and child rearing duties. They worked as long and as hard as men in support of their families and communities (Lee 1979: 260, 313 ff). Aborigines of Australia’s Western Desert derive some 80% of their dietary energy from plant foods harvested primarily by women, while Aborigines of the northern Australian coast depend heavily on shellfish, likewise gathered by women (Meehan 1982). The Columbia Plateau Indians of western North America—renowned for their prodigious salmon harvests—procured an estimated 65% of dietary calories from women’s harvests of tuberous roots and berries (Hunn 1981). Only at high latitudes does hunting contribute the bulk of dietary essentials, yet even the Inuit and Athabaskan hunting communities of northern North America depended heavily on women’s contributions in butchering meat, harvesting berries and greens, making and maintaining clothing, and not infrequently doing their own hunting.

The hunting hypothesis has misled also in conflating homicidal violence and warfare with the killing of prey by hunters. A careful ethnographic account of hunting by the Koyukon of the Koyukuk River in north central Alaska clearly demonstrates that hunting is first of all an intellectual pursuit depending on the hunter knowing his prey intimately and his local territory in fine detail (Lorenz 1966; Nelson 1969, 1973, 1983). Hunting furthermore requires great patience and is best pursued in a spirit of humility. Hunting seals at their breathing holes in the winter sea ice on Hudson’s Bay provides a powerful example, as in the film, “At the Winter Sea Ice Camp” (Balikci et al. 1967) documenting the last traditional winter hunting camp of the Netsilik Eskimo.

For many hunting peoples eating alone or refusing to share one’s food is morally repugnant and negatively sanctioned. Traditional subsistence hunters kill because they must. They show respect to the spirits; exhibiting arrogance or pride is punished by loss of hunting success and thus potential disaster. It is worth noting that the gathering of shellfish and plant foods and medicines—typically the province of women—likewise requires extensive empirical knowledge of hundreds of local species and a comprehensive appreciation of the local landscape. Thus arguments that hunting has driven the evolution of human intelligence rest on many false premises, including the one that only men, not women, should have evolved the cognitive capacities that set humans apart from other primates (e.g., Calvin 1983; Laughlin 1968).

The Dietary Role of Meat in Farming Societies

Some theorists have elaborated on the notion that humans evolved as meat-eating primates to argue that diets deficient in animal protein may be pathological. The most extreme version

of this view is Michael Harner's explanation for Aztec human sacrifice as a response to a shortage of animal protein. Harner argued that ritual cannibalism, said to have been an integral part of the Aztec human sacrificial complex, was intended to satisfy this craving for flesh (Harner 1977). Harner's argument has been widely and effectively discredited (e.g., Garn 1979; Hunn 1982b; Ortiz de Montellano 1978; Price 1978). Dietary protein may be obtained from sources other than big game, not only from fish and invertebrates but also from vegetal foods, particularly if processed to maximize the availability of amino acids and consumed with foods that complement the amino acid profiles of vegetal staples. In the case of the Aztecs, protein was unlikely to have been a limiting dietary factor, given the abundance of migratory birds, amphibians, fish, insects, and algae harvested from the lakes surrounding Tenochtitlán, the Aztec capital. Furthermore, the key staple grain, maize (*Zea mays* L.), was routinely prepared in an alkaline solution, liberating bound amino acids (Katz et al. 1974), and eaten with beans and amaranth, which complemented the amino acids deficient in maize (Ortiz de Montellano 1990: 98–119).

The dietary role of animal protein in many traditional horticultural and agricultural societies is limited. The Tsembaga Maring peoples of highland Papua New Guinea may get up to 99% of dietary calories from vegetal sources, despite high investment in pigs. Rappaport's *Pigs for the Ancestors* demonstrated that pig husbandry consumed more calories than it produced (Rappaport 1971). To account for this seeming irrational emphasis on pig husbandry, Rappaport developed the theory that protein from pigs was reserved for critical periods of intergroup conflict, thus enhancing a warrior's tolerance of stress (Rappaport 1984). Rather, it seems more likely that the Tsembaga exploit pigs as stored nutritional value that can be used in feasting as a social currency (as noted in Rappaport's afterword, 1984).

India's sacred cattle appear to involve an irrational reverence for an animal that is ecologically counterproductive, producing little meat yet competing with the human population for scarce resources. Marvin Harris argued in a classic essay that in fact the Hindu reverence for cattle is eminently rational given the many services cattle perform in the local agricultural economy, most notably as draft animals and as a source of dung for fuel and fertilizer (Harris 1965).

The Role of Animals Among Pastoralists

Pastoralists, like farmers, depend on domesticated species as primary food sources, yet, like hunters and gatherers, they are characteristically highly mobile. Pastoral societies also exhibit intermediate population densities. However, most pastoral societies appear to have developed as specialized adjuncts to intensive agricultural systems. Bedouin camel herders, for example, exchange surplus products with intensive farmers at desert oases, thus constituting but one segment of a complex symbiotic system of exchange (Sweet 1965). East African cattle herders, such as the Nuer, Karimojong, and Dodos, while placing great value on their cattle, nevertheless depend on sorghum (*Sorghum vulgare*) and millet (*Pennisetum typhoides*) for the bulk of their dietary calories (cf. Deshler 1965). Livestock provide meat, milk, and blood but also represent a form of money that may be banked for the future, exchanged for other material and social commodities, notably as bride price payments, which may be the groom's family's recognition of the value of the productive and reproductive powers of the wife (see, e.g., Evans-Pritchard 1940). Pastoral systems also allow communities to occupy marginal lands too dry or too cold for sustainable agriculture (e.g., Afghan Yak pastoralists; Shahrani 1976). Their success depends on the pride and

endurance for which pastoralists are justifiably famed but also on sophisticated knowledge of microhabitats, landforms, and pastures (Krohmer 2010).

Frederick Barth (1956) describes three ethnic groups occupying distinct cultural ecological niches in the Swat Valley of Pakistan, more recently the focus of attention as a Taliban refuge. The politically dominant Pathans practice intensive agriculture on the most fertile bottom lands of the valley. Displaced onto less productive lands, the Kohistanis practice a mixed farming–pastoral regime, tending sheep and goats to supplement their limited agricultural production. Meanwhile, the pastoral Gujars move their herds of sheep and goats from summer pastures high in the mountains to winter forage as clients of dominant Pathan families, providing in turn meat products and dung to fertilize Pathan fields.

Pastoralists have often been the subject of harsh criticism by development “experts”, either for the “inefficiency” of their productive regimes—as Harris notes with regard to Indian herders—or more often for the deleterious ecological impacts ascribed to their “overgrazing”. However, such criticism fails to consider how colonial governments both displaced and restricted traditional movements of pastoral groups, movements which had allowed herd forage requirements to be adjusted to available pasturage. The case of stock reduction programs imposed on Navajo sheep herders is a complex but instructive case in point (Weisiger 2008).

Similar critical judgments have been articulated with respect to sheep and goat herding. However, on closer examination, it is overstocking by frontier settlers and colonial entrepreneurs in Australia (Lines 1991) and Mexico (Melville 1994) that had the most devastating impact. By contrast, traditional goat husbandry in rural Portugal is a conservative practice that maintains soil fertility by recycling nutrients from unproductive matorral—where goats forage—to agricultural fields. Nitrogen-rich goat dung is collected overnight in house compounds on beds of vegetation, then periodically plowed into nearby fields (Estabrook 1998). Goats apparently play a similar role in the sustainable subsistence agriculture of certain Sierra Sur Zapotec communities in Oaxaca, Mexico. Here local farmers distinguish goat dung as “hot”, that is, associated with fertility, as opposed to the “cold” dung of donkeys (Hunn 2008: 143–144). This distinction reflects the contrast between ruminant and non-ruminant ungulates, ruminants digesting their forage far more thoroughly than non-ruminants, thus concentrating nutrients to a greater degree (Estabrook, pers. commun. 2002).

Conservation

Ethnozoologists are well placed to contribute substance to often polemical and hypothetical arguments with respect to the human impact on the natural world. Paul S. Martin, a paleontologist, promoted the view that human colonization of the Americas left a trail of massive extinction of megafaunal species (Martin 1967). Martin’s argument is widely popular and has been accepted as proven fact by many (cf. Diamond 1997: 44–50), though the evidence is circumstantial at best (Grayson 1984; Wolverton et al. 2009). Computer simulations purport to show how ancestral “Clovis big-game hunters” could have wiped out large and diverse populations of some 35 genera of ice age mammals. These simulations incorporate a number of wildly unlikely demographic and behavioral assumptions (e.g., Martin 1973; Whittington and Dyke 1984). For example, a demographic “shock wave” is envisioned propelled by a human population doubling every 20 years, a theoretical possibility but one that ignores the strict limits imposed by the need to carry infants and young children in mobile hunting-gathering societies (cf. Lee 1979: 320 ff, for the !Kung San). Pleistocene overkill

would require also that hunters pursue megafaunal prey far beyond their capacity to consume the animals they kill, in total disregard for the fact that it is difficult, dangerous work to stalk, wound, track, dispatch, and butcher such large animals. Proponents imagine that the hard work of overkill might be avoided by driving animals off cliffs, then cherry-picking the carcasses for the preferred cuts, leaving the bulk to rot. This ignores the fact that such cliff sites are few and far between in the Americas. Diamond cites an archaeological excavation of a prehistoric Folsom bison kill site in southern Colorado, the Olsen–Chubbok site, in support of his enthusiastic endorsement of Martin’s claim (Diamond 1997). However, a careful reading of Ben Wheat’s analysis shows just the opposite; 75% of the 200 bison killed were carefully disarticulated and another 15% partially butchered (Wheat 1967). Presumably the hunting band responsible was unable to consume every last pound of flesh, though they clearly made a valiant effort to do so. Hardly an example of “primitive profligacy”.

Martin’s thesis extrapolates from the well documented extinctions primarily of birds on Pacific Islands, from the giant flightless moas presumably exterminated by Polynesian colonists (Anderson 1984) to the loss of a significant fraction of Hawaii’s archeologically documented birds between Polynesian and European colonization (Olson and James 1984). Similar patterns of massive extinctions of island faunas prior to European colonization are evident from Madagascar to the Caribbean. What is as yet unclear is the various roles played in these extinctions by hunting, on the one hand, or by habitat alteration for agriculture, facilitated by systematic burning and the introduction of competitors, predators, and parasites on the other. However, it is certainly unjustified to equate the impact of colonists bringing the tools and perspectives of intensive farmers to a fragile, virgin island ecosystem with the potential impact of the Paleo-Indians who colonized the American supercontinent.

Martin’s Pleistocene Overkill scenario casts a long shadow over the continuing controversy about “conservation” among Indigenous peoples (Smith and Wishnie 2000). Opinion is sharply divided between those who presume that Indigenous communities are “just like us”, selfish profit maximizers who have no thought for the future, versus romantics who imagine Indigenous peoples as the “First Friends of the Earth”. The truth is certainly somewhere between these untenable extremes. Careful studies of contemporary Amazonian hunters suggest that they do not select their prey according to accepted wildlife conservation management protocols, but rather hunt opportunistically (Alvard 1995). However, one might argue that these particular hunters do not need to carefully husband their prey given their low population densities. On the other hand, subsistence practices of peoples at high densities are grounded in a sophisticated appreciation of the population dynamics of prey species, with harvests carefully regulated by tradition to maintain harvestable supplies for the future. The Huna Tlingit gull egg harvest strategy involves harvesting eggs from incomplete clutches of one or two eggs while sparing completed clutches of three (Hunn et al. 2003). There is indirect evidence that Icelandic peoples similarly husbanded waterfowl eggs over a period of many centuries (McGovern et al. 2007). In short, whether subsistence-based communities managed their harvests with the future in mind depends on a number of factors, such as the relative abundance of the prey species, the difficulty of monitoring local prey populations (e.g., in migratory or irruptive species), the effective political and/or legal control by the local community of its territory, and the effectiveness of social sanctions to inhibit “free riders” (cf. Smith and Wishnie 2000). Also important was the impact of colonization. Krech’s debunking of *The Ecological Indian* “myth” (Krech 1999) fails to adequately consider that the examples he cites of ecologically destructive impacts by American Indians, when not considerably exaggerated, are clearly consequent

to the disruption of local Native societies by intrusive Euroamerican enterprise (e.g., the beaver and bison harvests).

Pre-modern human societies radically altered the face of our planet. However, we must also recognize that the current precarious state of the global environment is attributable not to human nature but to particular cultural, social, and economic forces. Nor is it first of all a matter of the fact that the human population will soon exceed seven billion and continues to grow, though at a somewhat attenuated pace in recent decades. We must consider how these billions of humans consume the earth's resources, not only of food but of energy in all its forms. The "human footprint" is a function of the human population multiplied by *per capita* rates of energy consumption. By this standard the United States, with approximately 5% of the world's population, consumes more than 25% of the world's resources. How we relate to animals is central to understanding our "ecological footprint" (Wackernagel and Rees 1996).

Deforestation in the humid tropics has been blamed on the desperation of poor peasants seeking land to clear and plant, "slash and burn" farming assumed to be their destructive short-cut to survival. However, this involves a serious misplacement of blame. In Central and South America, at least, perhaps the major force for deforestation has been the demand for beef, to satisfy increasingly affluent urban populations in these countries or to generate foreign exchange. In some cases landless peasants are enticed to do the work of forest clearing in exchange for a year or two of low-rent subsistence farming, after which they are required to sow the depleted tropical soil with African forage grass seed. The land-owners—often wealthy urban residents—profit from government subsidies awarded those who "improve" undeveloped forest with a bare minimum of investment in land and labor (DeWalt 1982). Since the 1960s Central and South American nations have greatly expanded beef production at the expense of forest and fallow lands (Ledec 1992).

Animals are "Good to Think"

Animals are more than things to be named or eaten. Animals are fellow creatures that inspire our imaginations, people our sacred stories, inhabit our most fervent nightmares, and provide for us a mirror to contemplate who and what we are. Claude Lévi-Strauss proposed in *Totemism* (1963) that animal species—by virtue of the fact that they represent "lineages" of individual animals reproducing after their own kind yet existing within a larger community of species—were a particularly apt symbol for human lineages in unilineal societies (those calculating descent by exclusively male or female generational links). He concluded that animals become symbols not "because they are good to eat but because they are good to think". Tambiah added that, "Animals are good to think, and good to prohibit" (Tambiah 1969). Food taboos go far beyond the totemic realm and have long proved a challenge to scholars (Simoons 1961, Ross 1978). The biblical prohibitions outlined in Leviticus and Deuteronomy present a classic case study in our struggle to make sense of obscure cultural prejudices. Mary Douglas pursued a parallel line of argument to that of *Totemism* in *Purity and Danger* (1966), arguing that dietary prohibitions might best be explained as symbolic boundary markers, that prohibited species represent logical anomalies which threaten symbolic orderings. She explicitly rejected the then popular materialist explanation of the Hebrew prohibition on pork as a public health measure to avoid trichinosis. The priests of ancient Israel prohibited as "unclean" the flesh of pigs, camels, rock badgers, and hares of "the beasts that are on the earth" (Leviticus 11, 2–8). The ancient priests were quite explicit in their rationale. "Clean" beasts have cloven hooves and chew the cud. "Unclean" beasts do

one but not the other or neither. The hare, the “rock badger” (hyrax, a relative of the elephant) and the camel chew their cud but lack true cloven hooves, while swine have the appropriate hooves but fail to chew their cud. Thus, says Douglas, they threaten the symbolic order so precious to the priests. However, the “unclean” birds are less easily pigeon-holed (pardon the pun): “the eagle, the vulture, the osprey, the buzzard, the kite, after their kinds; the ostrich, the nighthawk, the sea gull, the hawk, after their kinds; the little owl and the great owl, the water hen and the pelican, the carrion vulture and the cormorant, the stork, the heron, after their kinds; the hoopoe and the bat. And all winged insects are unclean for you; they shall not be eaten” (Deuteronomy 14, 11–19). It is not clear what logical paradigm is transcended here. Rather it seems the unclean birds are rejected primarily because they are carnivorous, while bats and insects are marginal “birds” at best. But what of the hoopoe? It turns out that the hoopoe is noted for “fouling its nest” (another pun) (Hunn 1979).

Animism

Early social theorists constructed elaborate models of the progressive development of society from primitive, animal-like beginnings to the presumptive end-point, typically the culture and society of the European elite. Religion evolved from primitive worship of nature spirits, through elaborate polytheistic pantheons, to monotheistic world churches proclaiming universal truths. Durkheim (2008) saw in this a general principle: religions manifest the social experience of the societies that create them. “Acephalous” societies, that is, those without hierarchical leadership, worship a congeries of spirit powers, with no power in absolute control. Hierarchical societies, particularly those with elaborate bureaucratic power structures, imagine a hierarchy of spiritual authorities, systematically organized under a supreme deity. The charismatic shamans and prophets of “simpler” societies are suppressed by the rule of a priesthood, carefully vetted and distinguished by privileged access to sacred texts and arcane knowledge.

From this perspective “animism” was exiled to the outer reaches of the primitive mind. Animists, according to Tyler (1871), placated a plethora of spirits in nature, to curry their favor and avoid their spite. In my opinion this is a gross misrepresentation of the true spirit of animism. Animism is not a religion *per se* but rather a moral perspective most characteristically elaborated by hunting and gathering peoples, though evident among communities that depend as well on fishing and farming. Some claim that elements of animistic belief persisted among the central Mexican peoples of the Aztec empire (Ortiz de Montellano 1990).

The essential moral principle of an animistic perspective is this:

People, animals, plants, and other forces of nature—sun, earth, wind, and rock—are animated by spirit. As such they share with humankind intelligence and will, and thus have moral rights and obligations as PERSONS. (Hunn and Selam 1990: 230)

A deer hunter addresses the spirit of the deer requesting the gift of life. If the deer is well disposed to the hunter, if the hunter has acted respectfully in his prior dealings with deer, he will have luck in his hunting. If he should be arrogant or careless, he will have no luck. Coyote decreed this in a Columbia Plateau Indian story. Coyote kills a pregnant doe, then discards the fetuses as worthless. Coyote’s hunting luck deserts him; his family is in desperate straits, starving for want of game, until Coyote is advised of his error.

At times the requirements of respect border on Levitical precision in the handling of the animal’s body (Brightman 1973). A woman should never step over the carcass for fear of

contamination. The bones of a bear must be carefully hung up in a tree beyond the reach of dogs (Nelson 1983). The first salmon must be drained of blood and the first flesh shared as sacred; then the bones of the first salmon must be returned to the river to assure the salmon spirit will guide the fish home again (Gunther 1926). Humans belong to a wider, more comprehensive moral order that include as persons hunter and prey, bear and mouse, salmon in the rivers, roots and berries in the hills, the dueling summer and winter winds. Coyote with a capital “C” is the law-giver and messenger of the Creator.

Simple misunderstandings can seriously bias our reading of such stories. For example, to confuse “Raven” with “Crow” is to conflate the distinction in Plateau Indian perspective between the Raven—a chiefly bird with the power to tell of portentous events at a distance, if one is able to understand Raven talk—and “gossipy” crows. Golden Eagle (*Aquila chrysaetos*) and Bald Eagle (*Haliaeetus leucocephalus*) are clearly distinguished in the Sahaptin language on the Columbia Plateau as *xwaamá* versus *k’ámamul*. The first is a powerful, swift hunter; the second is a scavenger of dead fish. The animals in such stories are mythic persons with quite human powers of speech and human inclinations, the better to demonstrate to the children the pitfalls of pride and greed and the value of generosity. Yet they retain their animal character, acutely observed.

REFERENCES

- ALVARD M. Intraspecific prey choice by Amazonian hunters. *Curr Anthropol* 1995; 36:789–818.
- ANDERSON A. The extinction of moa in southern New Zealand. In: MARTIN PS, KLEIN RG, editors. *Quaternary extinctions: a prehistoric revolution*. Tucson: University of Arizona Press; 1984. 728–740.
- ANDERSON EN, MEDINA TZUC F. *Animals and the Maya in southeast Mexico*. Tucson: University of Arizona Press; 2005.
- ARDREY R. *The hunting hypothesis: a personal conclusion concerning the evolutionary nature of man*. New York: Atheneum; 1976.
- BALIKCI A, MARY-ROUSSELIERE M, BROWN Q, SMITH K. *The Netsilik Eskimo series* [documentary films]. Watertown (MA): Documentary Educational Resources; 1967.
- BARTH F. Ecologic relations of ethnic groups in Swat, North Pakistan. *Amer Anthropol* 1956; 58:1079–1089.
- BERLIN B. *Ethnobiological classification: principles of categorization of plants and animals in traditional societies*. Princeton (NJ): Princeton University Press; 1992.
- BLURTON-JONES N, KONNER MJ. !Kung knowledge of animal behavior (or: The proper study of mankind is animals). In: LEE RB, DEVORE, editors. *Kalahari Hunter-Gatherers*. Cambridge (MA): Harvard University Press; 1976. 325–348.
- BRIGHTMAN RA. *Grateful prey: Rock Cree human–animal relationships*. Berkeley: University of California Press; 1973.
- BROWN CH. Folk zoological life-forms: their universality and growth. *Amer Anthropol* 1979; 81:791–817.
- BULMER RNH. Folk biology in the New Guinea highlands. *Soc Sci Inform* 1974; 13:9–28.
- CALVIN WH. *The throwing Madonna: essays on the brain*. Columbus (OH): McGraw-Hill; 1983.
- CASTETTER EF, UNDERHILL RM. The ethnobiology of the Papago Indians. *Ethnobiological Studies in the American Southwest* 2. *Univ New Mexico Bull* 1935; 275:3–84. Reissued New York: AMS Press; 1978.
- CLÉMENT D. The historical foundations of ethnobiology (1860–1899). *J Ethnobiol* 1998; 18:161–187.
- DAHLBERG F, editor. *Woman, the gatherer*. London: Yale University Press; 1975.
- DEWALT B. The Big-Mac connection. *Cult Agric* 1982; Issue 14:1–12.
- DESCOLA P. *In the society of nature: a native ecology in Amazonia*. Cambridge: Cambridge University Press; 1994.
- DESHLER WW. Native cattle keeping in eastern Africa. In: LEEDS A, VAYDA AP, editors. *Man, culture, and animals*. Publication 78. Washington (DC): American Association for the Advancement of Science; 1965. 153–168.
- DIAMOND JM. Zoological classification system of a primitive people. *Science* 1966; 151:1102–1104.
- DIAMOND J. *Guns, germs, and steel: the fates of human societies*. New York: W.W. Norton; 1997.
- DOUGLAS M. *Purity and danger: an analysis of concepts of pollution and taboo*. London: Routledge & Kegan Paul; 1966.
- DURKHEIM E. The elementary forms of religious life. Oxford World Classics, 2008. In: CLADIS MS, editor; COSMAN C, translator. *Oxford World Classics* 2008. Oxford: Oxford University Press; 1912.
- ELLEN RF. Review of “Language and Living Things” by Cecil H. Brown. *Lang Soc* 1987; 16:123–130.
- ELLEN RF. *The cultural relations of classification: an analysis of Nuaulu animal categories from Central Seram*. Cambridge (UK): Cambridge University Press; 1993a.

- ELLEN RF. Nuauulu ethnozoology: a systematic inventory. Canterbury (UK): Centre for Social Anthropology and Computing, University of Kent at Canterbury; 1993b.
- ESTABROOK GF. Maintenance of fertility of shale soils in traditional agricultural system in central interior Portugal. *J Ethnobiol* 1998; 18:15–33.
- EVANS-PRITCHARD EE. *The Nuer*. New York: Oxford University Press; 1940.
- FORTH G. *Nage birds: classification and symbolism among an Eastern Indonesian people*. London: Routledge; 2004.
- GARN SM. The non-economic nature of eating people. *Amer Anthropol* 1979; 81:902–903.
- GRAYSON DK. Explaining Pleistocene extinctions: thoughts on the structure of a debate. In: MARTIN PS, KLEIN RG, editors. *Quaternary extinctions: a prehistoric revolution*, Tucson: University of Arizona Press; 1984. 807–823.
- GRIAULE M. *Conversations with Ogotemméli: an introduction to Dogon religious ideas*. London: Oxford University Press; 1965.
- GUNTHER E. An analysis of the First Salmon ceremony. *Amer Anthropol* 1926; 28:605–617.
- HARNER M. The ecological basis for Aztec sacrifice. *Am Ethnol* 1977; 4:117–135.
- HARRIS M. Cultural ecology of India's sacred cattle. *Curr Anthropol* 1966; 7:51–59.
- HENDERSON J, HARRINGTON JP. *Ethnozoology of the Tewa Indians*. *Bull Bur Am Ethnol* 1914; 56.
- HUNN ES. Tzeltal folk zoology: the classification of discontinuities in nature. New York: Academic Press; 1977.
- HUNN ES. The abominations of Leviticus revisited: a commentary on anomaly in symbolic anthropology. In: ELLEN RF, REASON D, editors. *Classifications in their social context*. London: Academic Press; 1979. 103–116.
- HUNN ES. On the relative contribution of men and women to subsistence among hunter-gatherers of the Columbia Plateau: a comparison with Ethnographic Atlas summaries. *J Ethnobiol* 1981; 1:124–134.
- HUNN ES. The utilitarian factor in folk biological classification. *Amer Anthropol* 1982a; 84:830–847.
- HUNN ES. Did the Aztecs lack potential animal domesticates? *Am Ethnol* 1982b; 9:578–579.
- HUNN ES. The use of sound recordings as voucher specimens and stimulus materials in ethnozoological research. *J Ethnobiol* 1992; 12:187–198.
- HUNN ES. *A Zapotec natural history: tree, herbs, and flowers, birds, beasts, and bugs in the life of San Juan Gbëë*. Tucson: University of Arizona Press; 2008.
- HUNN ES, JOHNSON D, RUSSELL P, THORNTON TF. Huna Tlingit traditional environmental knowledge, conservation, and the management of a “wilderness” park”. *Curr Anthropol* 2003; 44(S5):79–104.
- HUNN ES, SELAM J. Nch'i-Wa'na “The Big River”: Mid-Columbia Indians and their land. Seattle: University of Washington Press; 1990.
- INGOLD T. The optimal forager and economic man. In: *The perception of the environment: essays in livelihood, dwelling and skill*. London: Routledge; 2000. 27–39.
- JOHANNES RE. *Words of the lagoon*. Berkeley: University of California Press; 1981.
- JOHNS T. *With bitter herbs they shall eat it: chemical ecology and the origins of human diet and medicine*. Tucson: University of Arizona Press; 1990.
- KATZ SH, HEDIGER ML, VALLEROY LA. *Traditional maize processing techniques in the New World*. Science 1974; 184:765–773.
- KRECH S III. *The ecological Indian: myth and history*. New York: W.W. Norton; 1999.
- KROHMER J. Landscape perception, classification and use among Sahelian Fulani in Burkina Faso (West Africa). In: JOHNSON LM, HUNN ES, editors. *Landscape ethnoecology: concepts of biotic and physical space*. New York and Oxford: Berghahn; 2010. 49–82.
- LAUGHLIN WS. Hunting: an integrating biobehavior system and its evolutionary importance. In: LEE RB, DEVORE I, editors. *Man the hunter*. Chicago (IL): Aldine; 1968. 304–320.
- LEDEC G. New directions for livestock policy: an environmental perspective. In: DOWNING TE, HECHT SB, PEARSON HA, GARCIA-DOWNING C, editors. *Development or destruction: the conversion of tropical forest to pasture in Latin America*. Boulder (CO): Westview Press; 1992. 27–65.
- LEE RB. *The !Kung San: men, women, and work in a foraging society*. Cambridge (UK): Cambridge University Press; 1979.
- LEEDS A, VAYDA AP. Man, culture, and animals: the role of animals in human ecological adjustments. Publication 78. Washington (DC): American Association for the Advancement of Science; 1965.
- LEVI-STRAUSS C. *Totemism*. Boston (MA): Beacon Press; 1963.
- LINES WJ. *Taming the Great South land: a history of the conquest of nature in Australia*. Athens: University of Georgia Press; 1991.
- LORENZ K. *On aggression*. New York: Harcourt, Brace, and World; 1966.
- MAJNEP IS, BULMER RNH. *Mnmon Yad Kalam Yakt [Birds of My Kalam Country]*. Auckland (NZ): Auckland University Press & Oxford University Press; 1977.
- MAJNEP IS, BULMER R. *Animals the ancestors hunted: an account of the wild mammals of the Kalam area, Papua New Guinea*. Adelaide, Australia: Crawford House; 2007.
- MARSHALL J. *The hunters [documentary film]*. Watertown (MA): Documentary Educational Resources; 1957.
- MARTIN PS. Pleistocene overkill. *Nat Hist* 1967; 7:32–38.
- MARTIN PS. The discovery of America. *Science* 1973; 179:969–974.
- MASON OT. Aboriginal American zoötechny. *Amer Anthropol* 1899; 1:45–81.
- MCGOVERN TH, VÉSTEINSSON O, FRIDRIKSSON A, CHURCH M, LAWSON I, SIMPSON IA, EINARSSON A, DUGMORE A, COOK G, PERDIKARIS S, EDWARDS K, THOMSON AM, ADLERLEY WP, NEWTON A, LUCAS G, ALDRED O. Landscapes of settlement in Northern Iceland: historical ecology of human impacts and climate fluctuation on the millennial scale. *Amer Anthropol* 2007; 109:27–51.

- MEEHAN B. Shell bed to shell midden. Canberra: Australian Institute of Aboriginal Studies; 1982.
- MELVILLE EGK. A plague of sheep: environmental consequences of the Conquest of Mexico. Cambridge (UK): Cambridge University Press; 1994.
- NELSON RK. Hunters of the Northern ice. Chicago (IL): University of Chicago Press; 1969.
- NELSON RK. Hunters of the Northern Forest. Chicago (IL): University of Chicago; 1973.
- NELSON RK. Makes prayers to the raven: a Koyukon view of the Northern Forest. Chicago (IL): University of Chicago Press; 1983.
- OLSON SL, JAMES HF. The role of Polynesians in the extinction of the avifauna of the Hawaiian Islands. In: MARTIN PS, KLEIN RG, editors. Quarternary extinctions: a prehistoric revolution. Tucson: University of Arizona Press; 1984. 768–780.
- ORTIZ DE MONTELLANO BR. Aztec cannibalism: an ecological necessity? *Science* 1978; 200:611–617.
- ORTIZ DE MONTELLANO BR. Aztec medicine, health, and nutrition. New Brunswick (NJ): Rutgers University Press; 1990.
- POSEY D. Wasps, warriors, and fearless men: ethnoentomology of the Kayapo Indians of Central Brazil. *J Ethnobiol* 1981; 1:165–174.
- PRICE BJ. Demystification, enriddlement, and Aztec cannibalism: a materialist rejoinder to Harner. *Am Ethnol* 1978; 5:98–115.
- RAMSEY J, editor. Coyote was going there: Indian literature of the Oregon County. Seattle: University of Washington Press; 1977.
- RAPPAPORT R. The flow of energy in an agricultural society. *Sci Am* 1971; 225:116–132.
- RAPPAPORT R. Pigs for the ancestors: ritual in the ecology of a New Guinea people. 2nd ed. New Haven (CT): Yale University Press; 1984.
- RAWLINSON G, translator. The history of Herodotus. New York: Tudor; 1928.
- REA AM. Folk mammology of the Northern Pimans. Tucson: University of Arizona Press; 1998.
- REA AM. Wings in the desert: a folk ornithology of the Northern Pimans. Tucson: University of Arizona Press; 2007.
- ROSS EB. Food taboos, diet, and hunting strategy: the adaptation to animals in Amazon cultural ecology. *Curr Anthropol* 1978; 19:1–16.
- RUDDLE K. The human use of insects: examples from the Yukpa. *Biotropica* 1973; 5:94–101.
- SHAHRIANI N. Kirghiz pastoral nomads of the Afghan Pamirs: a study in ecological and intra-cultural adaptations [PhD dissertation]. Seattle: University of Washington; 1976.
- SIMOONS FJ. Eat not this flesh: food avoidances from prehistory to the present. Madison: University of Wisconsin Press; 1961.
- SMITH EA. Inujjamiut foraging strategies: evolutionary ecology of an Arctic hunting economy. New York: Aldine de Gruyter; 1991.
- SMITH EA, WISHNIE M. Conservation and subsistence in small-scale societies. *Annu Rev Anthropol* 2000; 29:493–524.
- SWEET LE. Camel pastoralism in North Arabia and the minimal camping unit. In: LEEDS A, VAYDA AP, editors. Man, culture, and animals. Publication 78. Washington (DC): American Association for the Advancement of Science; 1965. 129–152.
- TAMBIAH SJ. Animals are good to think and good to prohibit. *Ethnology* 1969; 7:423–459.
- TANNER A. Bringing home animals: religious ideology and mode of production of the Mistassini Cree hunters. New York: St. Martin's Press; 1979.
- TYLER EB. Primitive culture. London: Murray; 1871.
- WACKERNAGEL M, REES W. Our ecological footprint: reducing human impact on the Earth. Gabriola Island (BC): New Society Press; 1996.
- WADDY JA. Biological classification from a Groote Eylandt Aborigine's point of view. *J Ethnobiol* 1982; 2:63–77.
- WADDY JA. Classification of plants and animals from a Groote Eylandt Aboriginal point of view. Darwin: Australian National University; 1988.
- WALTER EA. Dogon restudied: a field evaluation of the work of Marcel Griaule. *Curr Anthropol* 1991; 32:139–167.
- WEISIGER ML. Dreaming of sheep in Navajo Country. Tucson: University of Arizona Press; 2008.
- WHEAT JB. A Paleo-Indian bison kill. *Sci Am* 1967; 216(1):43–52.
- WHITTINGTON SL, DYKE B. Simulating overkill: experiments with the Mosimann and Martin model. In: MARTIN PS, KLEIN RG, editors. Quarternary extinctions: a prehistoric revolution. Tucson: University of Arizona Press; 1984. 451–465.
- WILSON EO. The insect societies. Cambridge (MA): Belknap; 1971.
- WOLVERTON S, LYMAN RL, KENNEDY JH, LA POINT TW. The terminal Pleistocene extinctions in North America, hypermorphic evolution, and the dynamic equilibrium model. *J Ethnobiol* 2009; 29:28–63.
- WYMAN LC, BAILEY FL. Navajo Indian ethnoentomology. Albuquerque: University of New Mexico Press; 1964.

Chapter 7

Ethnobiology, Historical Ecology, the Archaeofaunal Record, and Interpreting Human Landscapes

PETER W. STAHL

Department of Anthropology, Binghamton University, Binghamton, NY

INTRODUCTION	97
ZOOARCHAEOLOGICAL METHODS	99
ARCHAEOLOGICAL RECOVERY	100
SPECIMEN IDENTIFICATION	101
PERIMORTEM ASSEMBLAGE ACCUMULATION AND DEPOSITION	101
POSTMORTEM ACCUMULATION, DISPERSAL, AND DESTRUCTION	103
EQUIFINALITY	104
ZOOARCHAEOLOGICAL INTERPRETATION OF PAST LANDSCAPES	105
SUBSISTENCE INTERPRETATION	105
PALEOECOLOGICAL INTERPRETATION	106
AN ARCHAEOLOGICAL EXAMPLE: ARCHAEOFAUNAL ACCUMULATION IN WESTERN EQUADOR	107
SUMMARY AND DISCUSSION	111
REFERENCES	112

INTRODUCTION

The interrelationship between past human cultures and their surroundings is critically important for interdisciplinary ethnobiological study, and interpreting preserved organic residues recovered in an archaeological context is essential for answering significant research

questions about the production and maintenance of human landscapes. How pervasive was the human footprint, and what is the nature and importance of human landscapes in different areas and at different times? How and why is this significant for our understanding of contemporary biodiversity and its conservation? What lessons can we learn from past landscape management that we can apply to contemporary settings? What are the implications of past landscape domestication for contemporary human populations? The answers to these questions have wide-ranging practical as well as moral implications.

Bioarchaeological data include preserved plant and animal specimens recovered from buried contexts that were originally accumulated and deposited by, or in the presence of, humans. As our primary data consist of the intentional and incidental byproducts of human landscape manipulation, we function within the research program of historical ecology (Balée 2006). Historical ecology is part of a broader paradigmatic shift that incorporates disequilibrium and contingency in contrast to the functionalism of equilibrium-based ecology. It can also be differentiated from allied ecological viewpoints by the weight it ascribes to the cumulative effect of human activity on the landscape, which is regarded as a medium intentionally created by and for human use. Historical ecology emphasizes the key role played by humans in shaping biodiversity and maintaining intermediate levels of disturbance which are fundamental to ecosystem health. As well as adapting to particular environments, cultures create and manage landscapes that meet their needs; this can result in either decreased or increased diversity depending upon local requirements. When we analyze preserved plant and animal remains and attempt to interpret past anthropogenic landscapes, our intention is to understand the logic that was once expressed in Indigenous knowledge and used to create and manage resources. Archaeologists study “patterns of residues, anomalies, and cultural imprints (as palimpsest) of humans on the landscape” which comprise the primary data of historical ecology (Balée and Erickson 2006: 7). We therefore approach the “environment” like any other human artifact encountered in the buried record, at different scales of analysis but principally on the level of the landscape (Balée 1994, 1998, 2006; Balée and Erickson 2006; Crumley 1994; Erickson 2006, 2008; Janzen 1998).

Zooarchaeologists analyze animal bone specimens recovered from excavated contexts to interpret earlier human subsistence and associated ecological contexts in different places and times. Preserved archaeofaunal assemblages include two related subsets of skeletal specimens: (1) those originating as discarded byproducts of animals that were intentionally accumulated by humans for subsistence purposes; and (2) those originating through nonhuman accumulation that may or may not have been incidental to human activities, and which implicate a potentially wide range of accumulating mechanisms like pit fall, fossorial death, hydrodynamic sorting, and nonhuman predation and deposition. Both subsets can be relevant for either objective, as the interpretation of paleoecological contexts can include inferences derived from culturally and non-culturally accumulated specimens; however, most subsistence interpretations are based on observations derived from analyzing specimens that were accumulated by humans for dietary or other purposes.

Although it may seem intuitively obvious, it should be stressed that recovered specimens in both archaeofaunal subsets never constitute a complete sample of the animals that were associated with any area or time of archaeological interest (Fig. 7.1). Specimens in the assemblage were selectively accumulated and deposited by human and nonhuman consumptive behaviors, and through the shared ecology of certain animals whose habits contributed to their eventual inclusion in excavated contexts. A potentially wide range of variables can subsequently modify the spatial arrangement and/or qualitative and quantitative character of the deposited assemblage before and after its burial and eventual recovery in archaeological excavation (e.g., Clark and Kietske 1967; Grayson 1981; Lyman 1987a,

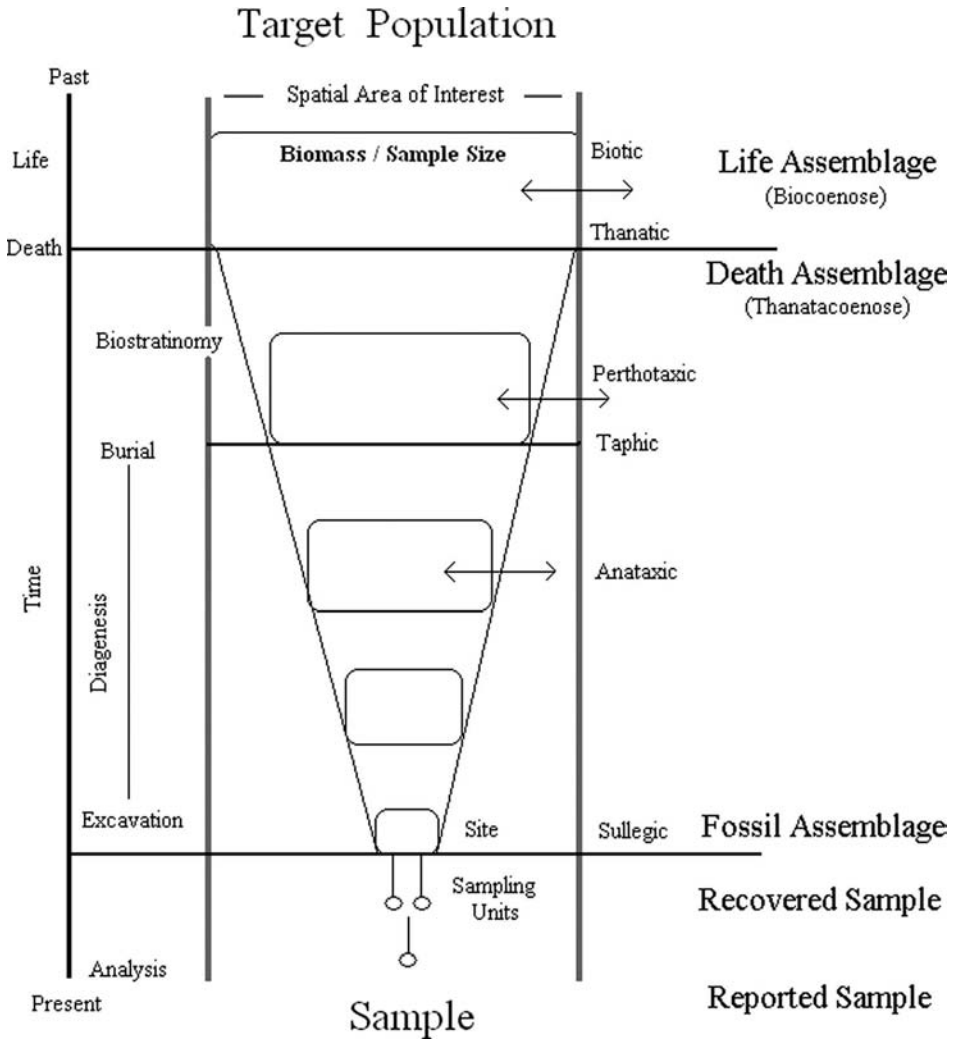


Figure 7.1 A schematic taphonomic framework emphasizing the relationship between the studied archaeological sample and the target population of interest. Sample size tends to decrease throughout the ontogeny of assemblage formation from initial accumulation to archaeological recovery and analysis.

1994; Shipman 1981; Wilson 1988). Although both subsets of the assemblage are essential for interpretation, it is important to consider their different accumulation histories before they can be linked to the past target population of interest. This involves using *taphonomy*, the study of what happens to animal remains after death. Valuable clues about taphonomic history are accessed through the study of archaeologically recovered specimens and their associated depositional contexts.

ZOOARCHAEOLOGICAL METHODS

The relationship between target and sample populations must be critically evaluated in order to gauge how well or poorly, and in what way, a recovered and identified sample represents

the assemblage that was originally accumulated and deposited in any area and time of interest. The relationship is never isometric, as the sample assemblage is altered through subtraction, addition, and/or spatial rearrangement during the period between deposition and recovery (Fig. 7.1). Contributing factors can include: how archaeological specimens are recovered; limitations of osteological identification; and various modes of perimortem and postmortem accumulation, deposition, dispersal, and destruction that can affect assemblage formation. During analysis, zooarchaeologists search for clues or signatures in the preserved study sample and its associated archaeological context, which might be useful for assessing the sample's relevance to research questions. However, we are mindful of the pervasive caveat of equifinality (similar outcome produced by different events), as multiple effects may be produced by one process, similar effects may be produced by different processes, or previously observable effects may become obscured through subsequent assemblage formation.

Archaeological Recovery

The quality and quantity of information available in the sample assemblage is strongly affected by how specimens are recovered in the field. Different recovery techniques and variable screen aperture size alter basic characteristics of the archaeological sample. The most obvious change is in the relative abundance and proportional representation of smaller specimens. Sample recovery using fine aperture mesh increases the likelihood of identifying smaller animals, many of which may have lived in the immediate vicinity of assemblage accumulation and deposition. This fraction of the archaeofaunal assemblage can be very important for providing clues about local conditions in the archaeological area of interest. Intensive recovery often increases the relative proportion of sample specimens that cannot be identified beyond a certain level of taxonomic acuity because they were fragmented to a size too small for reliable identification. In these instances, biomolecular analyses may prove to be the only recourse.

The presence or absence of an animal, or clues about its subsequent taphonomic history, can be affected simply by how specimens were recovered. Subsequent processing and handling can augment fragmentation or obscure clues about the assemblage's taphonomic history. Fragmentation is of relevance for our interpretations only when it is not the product of archaeological recovery and processing. This can usually be identified by the fresh coloration of recent fracture surfaces. These issues can affect our counting statistics and estimations of assemblage diversity.

Results from actualistic (analogically inferring past events from present observable processes) studies can be used to gauge the effects of recovery bias on assemblage representation. These can include the application of correction factors based upon the nested screening of skeletal elements from animal taxa expected to appear in the recovered sample (Thomas 1969), or through comparison of retrieved samples with known totals recovered via water screening (Watson 1972). Shaffer (1992; Shaffer and Sanchez 1994) presents useful results that were derived from screening complete skeletons of variously sized animals through different aperture sizes. We can compare these data with the size of aperture used to recover our sample in order to estimate whether or not the presence or absence of individual skeletal elements in the assemblage might be attributed to recovery in the field. For this purpose, measurements of length, width, and depth of each specimen might also be useful for estimating the nature and extent of assemblage loss due to field recovery (Stahl 2008a). Other kinds of evidence that can be important for understanding

assemblage accumulation and deposition are found in archaeological contexts and should be observed during the course of field recovery. These can include notation of skeletal articulation, intrusion based on soil discoloration (disturbance, krotovinas, or infilled animal burrows, etc.), and spatial or vertical association of specimens in feature contexts.

Specimen Identification

Specimen identification, which is fundamental to the primary goals of zooarchaeology, is not a straightforward exercise (Driver 1992). At issue is the basic disjuncture between the criteria that zoologists use to construct taxonomies and the nature of preserved archaeological data. With the exception of cranial anatomy and dentition, systematists base their inferences about natural populations on criteria that are normally not preserved in the archaeological record. As a result, certain portions of the vertebrate skeleton, especially highly durable teeth, tend to have greater diagnostic resolution than others. Due to aspects of differential preservation, denser element portions which are relatively resistant to fragmentation often retain diagnostic landmarks that can enhance identification. Fragmentation can obscure identification by producing specimens which are too small to be reliably identified at different levels of zoological acuity. This is most often associated with relative body size, as tiny specimens from small-bodied animals may still be large enough for identification, whereas larger-bodied animals often yield larger non-identifiable fragments (Watson 1979).

Many factors can contribute to variation in specimen identification. Whereas the basic zoological systematics of certain taxa may be poorly understood or osteological variation within and between some populations may be unknown, other animals may be highly identifiable due to specific unique skeletal characteristics. Often, osteological criteria for differentiating closely related taxa may be obscure or arbitrary. It is not uncommon for identification to be based on other factors like specimen size, geographical or temporal context, the relative experience of the analyst, or what kind of comparative material is available in the consulted collection. In any or all of these cases it might be best to use ascending taxonomic levels of inclusive identification, with specimens identified to *Genus*, Family, Order, Class, and so on, with a further caveat that taxonomies are never immutable but constantly adjusted. The qualitative and quantitative structure of the study sample, how representative it is of our target of interest, and its overall interpretive utility for our research questions, are direct outcomes of specimen identification.

Perimortem Assemblage Accumulation and Deposition

The relationship between the sample and target of interest is initiated when assemblages are accumulated and deposited. Archaeological reconstruction of human subsistence is based upon that subset of available fauna specifically selected for consumption; therefore, it focuses primarily on those specimens in the sample which can be reliably related to this target of interest. It is thus necessary to separate the animals selectively accumulated for humans' use from those whose accumulation and deposition were incidental to human consumption. Both subsets can be relevant for landscape reconstruction because specimens that are incidental to human consumption can provide information about local conditions in the immediate area of deposition, and specimens produced in the course of human consumption can also provide information about conditions in areas from which they were originally procured. Nonetheless, the entire sample assemblage is never a complete representation of the

animals that lived in the general area and time of archaeological interest because of the selective nature of accumulation and deposition. Associated evidence for different modes of accumulation can be preserved in the buried record.

Most archaeological assemblages include specimens of animals whose accumulation and deposition were incidental to human activity at the time of occupation, or had intruded into archaeological contexts after site abandonment. Often, these animals consist of smaller commensal taxa, especially rodents, which thrive in conditions created by humans and are generally treated as nuisance rather than as prey. They are often included into deposits as the result of death through accidental entrapment, fires, floods, and collapsed underground burrows. These specimens can be of particular interest for paleoecological interpretation as they often represent depositionally proximate faunas whose presence in the assemblage may be relevant for interpreting local conditions.

Various characteristics of the preserved sample and its associated archaeological context can aid in the identification of these specimens. High concentrations of preserved specimens that represent all or most anatomical portions of the skeleton can suggest accidental death and subsequent decay. This is supported by relative completeness with little perimortem damage to the skeleton, and can be further corroborated by anatomical articulation. Very often archaeologists rely on bone coloration as a clue to intrusion, particularly when it is quite distinct from the rest of the assemblage. For example, pale coloration (especially relative to other specimens) is often assumed to be a characteristic of intrusive specimens; however, this does not necessarily establish if the intrusion occurred before, during, or after assemblage accumulation. Associated archaeological context is crucial for interpreting the mode of accumulation, such as the presence of visible soil krotovinas (filled rodent holes) or vertical and spatial association with features that facilitate entrapment and inhibit escape. Ecological characteristics of identified taxa are important for interpretation, including food and habitat preferences, locomotor habits, gregariousness, and any characteristics that might facilitate susceptibility to accidental accumulation and deposition (Andrews 1990; Stahl 1996; Whyte 1991).

Archaeofaunal assemblages include bone specimens that were deposited through the accumulation and modification of prey items by human and nonhuman predators. Although either prey sample was selectively removed from its surroundings, both can provide background information on conditions in areas from which they were procured. Prey taxa can be identified through digested bone specimens deposited in scats and pellets; predators can also be identified through specific modifications that occurred during capture, consumption, and digestion. Actualistic study of different predators can provide clues to the identity of the accumulator from digested bone based on modification during consumption. This can include tooth marks, acid etching, patterned bone fragmentation, skeletal element representation, adhering scat material, the archaeological context of deposition, and ecological information about the identified prey. Identifications are strengthened through use of multiple criteria (Andrews 1990; Andrews and Evans 1983; Butler and Schroeder 1998; Crandall and Stahl 1995).

Nonhuman carnivores frequently accumulate, modify, spatially rearrange, and deposit bone specimens in archaeological contexts. This can occur before and after humans abandon the site or during its occupation, especially when domestic dogs are present. Their involvement in assemblage formation is identified through preserved evidence in the bone assemblage, and compared to the results of actualistic studies focused on carcass reduction and consumption by carnivores. Tooth marks are common on comminuted bone, and their morphology, frequency, and orientation are noted, along with representation of preserved skeletal parts. Archaeological context and the identification of the potential nonhuman

accumulator from bone specimens in the assemblage can also be important (Binford 1981; Brain 1981).

Evidence for bone accumulation, modification, and deposition by humans often involves a wider range of potential data, primarily because of the variety of techniques and practices involved in cultural consumption. Preserved evidence on bone specimens can include features of bone breakage, marks left primarily by tools and in some cases by teeth, and carcass disarticulation. The location and morphology of breakage, the nature of the breakage surface, and any evidence for what might have caused the breakage are noted. However, patterned breakage can be equivocal as it is often governed by osteological properties of bone rather than the event that contributed to its breakage. Butchery scars produced by tools are generally rare, and noted for their location, orientation, and morphology. Various attributes of mark morphology, including shape, frequency, and orientation are recorded. The interpretation of patterned disarticulation suffers from the same problems as breakage because it tends to be controlled by anatomical variables rather than the process responsible for its disarticulation (Hill 1979; Lyman 1987b).

Archaeologists often consider bone modified through exposure to heat as evidence for human consumption. However, evidence of exposure to heat is not necessarily a product of cooking because many techniques impart no visible signs of heat modification on bone specimens. Humans intentionally expose flesh to heat more often than bone, except during marrow extraction. Patterned burning of bone may appear on portions of bone that are exposed to heat while meat is being processed. However, many techniques used in cooking often leave no trace of direct heat modification on bone, which is very often the result of intentional disposal of garbage or when it is used as fuel. Archaeologists record the extent, color, and anatomical location of heat modification. Differential coloration can be particularly useful as it is associated with the amount of combusted bone organic matter. Comparisons of bone specimens with published actualistic studies that record the color reached at different temperatures can independently assess the degree of exposure to heat (Shipman et al. 1984).

Although usually rare in the archaeological record, potentially unambiguous evidence for human use consists of preserved bones that were modified into tools. The animal and element from which they were fashioned are identified, and associated ecological and ethnographic information are used for interpretive purposes: was it a potential dietary item? commensal? domesticate? The archaeological context of the deposited assemblage is also important for interpretation: was it recovered from a trash pit, midden, hearth, house floor, cache, butchery site, or elsewhere? In all cases, we can mitigate the potential problem of equifinality through the use of multiple lines of evidence, which in turn strengthen the inference.

Postmortem Accumulation, Dispersal, and Destruction

The taphonomic history and potential for increased skeletal disorganization of a bone assemblage continues during exposure prior to burial. Fluvial transport can spatially rearrange and modify assemblages by alternately winnowing or accumulating exposed specimens. Water moving at increasing velocities over various substrates can differentially sort deposited bone corresponding to specimen size, shape, and density. Elements of small skeletons are particularly prone to dispersal through even low velocity sorting. Evidence for hydrodynamic sorting can be found in the patterned orientations of bone assemblages, modification through abrasion, shared physical characteristics associated with water movement, and an

analysis of sediment matrix in archaeological contexts (Behrensmeyer 1975; Dodson 1973; Voorhies 1969).

Bone specimens are also accumulated by non-carnivores for mineral consumption and dental maintenance in cases where high crowned or ever-growing teeth are in need of filing. Rodents and artiodactyls can leave distinct tooth marks which are often highlighted by coloration that is different from the rest of accessible bone surfaces. Archaeological context, and a specimen's size, shape, and condition can also offer clues about the identity of the bone collector. Trampling of exposed assemblages can also produce breakage, surface modification, size sorting, and vertical or horizontal movement. Weathering and desiccation of exposed bone can lead to bleaching, cracking, exfoliation, and eventual disintegration of bone material over time. Taphonomists typically monitor the degree of surficial weathering as a proxy for estimating the duration of assemblage exposure and interpreting ambient conditions prior to burial. Patterned weathering can be used as a potential clue for interpreting sequential burial/re-exposure and for recognizing attritional and catastrophic accumulation (Behrensmeyer 1975; Lyman and Fox 1989).

Alteration of archaeological bone assemblages continues after burial. Chemical dissolution of bone proceeds through a complex interaction between microbial activity, soil chemistry, water, and temperature, combined with physical characteristics of the buried specimen, especially its size, shape, state of fragmentation, exposure of interior surfaces, and relative porosity. The burial environment can also substitute or add materials to the bone specimen, and contribute to breakage or vertical and spatial movement through overburden pressure and compaction. Chemical assays, fracture morphology, coloration, surface modification, conjoinability, actualistic study of buried bone, and archaeological context are examined to infer influences produced in the relative black box of diagenesis (Hedges 2002).

Equifinality

The use of preserved evidence to identify aspects of assemblage formation history and for assessing the relationship between sample and target is often confounded by equifinality. Evidence that may have been available at one point in an assemblage's taphonomic history may have been subsequently obscured by later processes. More perniciously, one taphonomic process may produce many different kinds of preserved effects, whereas one kind of preserved effect may be produced by many different taphonomic processes. Despite these ubiquitous problems, we attempt to identify different modifying factors, understand their origin, order their sequence, and evaluate their importance for assemblage preservation/destruction as best we can.

Bone destruction and preservation are of cardinal importance to zooarchaeological research. Although we can study the various processes that contribute to destruction and preservation, bone survivorship is strongly influenced by the differential structural density of its component parts. Harder portions tend to have a greater chance of survival; fragile portions tend to be more prone to destruction. Bone survivorship is an important example of an equifinal outcome in which one pattern can be produced by many different factors. In order to achieve some understanding of bone survivorship and how sample specimens compare to complete skeletons, zooarchaeologists employ measurements of bone structural density which can evaluate the nature and degree to which sample preservation has been mediated by differential density. Taphonomists have used various methods to measure bone structural density in different animal skeletons. It has become somewhat routine to compare the

survivorship of sample specimens with these density values in order to assess whether or not assemblage preservation was influenced by attritional forces whose effects were mediated by the structural density of bone throughout the skeleton. The procedure is not without its problems, but can be used as a first-order approximation for exploring assemblage survivorship. Although this approach may implicate an underlying cause for preservation, we still rely on observations of the recovered sample and its archaeological context for uncovering evidence to suggest more proximate reasons as to why the sample preserved in the way that it did. The likelihood of a correct assessment of assemblage survivorship is strengthened through corroboration from multiple lines of evidence (Brain 1981; Lam and Pearson 2004; Lyman 1994)

ZOOARCHAEOLOGICAL INTERPRETATION OF PAST LANDSCAPES

Subsistence Interpretation

If we can reliably identify the portion of a recovered assemblage that was originally accumulated and deposited by humans for their consumption, then we can ask questions appropriate to human subsistence. However, we must be aware that quantitative and qualitative differences in the studied assemblage can result from factors that contributed to its modification during the time between original accumulation and eventual analysis. The basic analytical unit for all subsequent inferences is the NISP (Number of Identified Specimens) of animal taxa that is relevant to inferences about prehistoric consumption. However, different values of NISP can vary for reasons that are unrelated to inferences about subsistence. These differences may be due to factors associated with specific animals or skeletal elements, and are often strongly affected by fragmentation, differential preservation, and techniques of field recovery (Grayson 1981).

Subsistence inferences based solely on NISP are often misleading. Normally, NISP is presented alongside an estimate of the Minimum Number of Individuals (MNI) of a given taxon required to account for the NISP of that taxon in the sample. In its simplest form, MNI is equal to the highest number of either left or right paired element portions for each given taxon. The Minimum Number of Elements (MNE) is similarly computed without distinguishing body side, and can be easily converted into Minimum Animal Units (MAU), which relate the MNE to individual body portions. Although not without their attendant problems, these derived permutations of NISP offer units of analysis that are more useable for questions about diet. Increasingly robust and reliable inferences about dietary contribution are possible when coupled with appropriate utility indices, which consist of empirically determined estimates of total food value represented in different skeletal portions of different animal taxa (Binford 1978).

Archaeological data can help us to identify what kinds of animals humans exploited, which sexes or ages were preferred and when, where, and how they were procured, processed, and consumed. Nevertheless, the exact quantitative relationship between the recovered and deposited samples remains unknown. Moreover, we can never be certain how representative the deposited assemblage is of the original sample of animals that was procured and consumed by humans. Therefore, it is usually difficult to establish anything but a rough estimate of relative dietary contribution.

Paleoecological Interpretation

If we can establish how the recovered assemblage was originally accumulated and deposited, and understand how attributes of the study assemblage reflect biases introduced by the accumulating agent, then we can ask questions appropriate to paleoecology. Again, we must be aware that quantitative and qualitative differences in the studied assemblage result from factors that contributed to its modification during the time between original accumulation and eventual analysis. However, we can never be certain that the quantitative structure of our recovered sample accurately reflects either the structure of the original accumulation or a hypothetical population of animals in the past.

Archaeological interpretations of former landscapes are based on relational inferences that we construct by linking repeated observations between contemporary processes and their resultant effects. If we can recognize similarities between contemporary objects and our sample of recovered, identified, and analyzed specimens in their associated archaeological context, we can infer the likelihood of a similar relationship holding for the past (Lyman 1994: 64). The inferential logic of paleoecology relies heavily on contemporary observations of organisms and actualistic studies which we link to our identifications in the recovered sample. The spatial and temporal controls provided by archaeological context allow us to project these inferences onto a target of archaeological interest in a specified place and time. Although analogical relationships are commonly used in retrodiction, they may become seriously flawed by limitations in the archaeological samples and misinterpretation of the relationship between the recovered sample and the target of interest.

Findley (1964) has identified four problems of immediate relevance to inference building in archaeology.

- 1 The analogical relationship often requires high resolution identifications. Most animals are polytypic and have different ecologies and unique habits at the species level or lower. Higher level identifications (*Genus*, Family, Order), although entirely appropriate for purposes of identification, may not be accurate enough for analogy building.
- 2 Although a specimen may be identified with sufficient resolution, the available ecological data may be poorly known or inadequate for our purposes.
- 3 Many animal taxa are eurytopic, or widely distributed and broadly tolerant of a wide range of ecological conditions. Although stenotopic organisms, which tolerate only a narrow range of conditions, are preferred by paleoecologists for high resolution inferences, I argue below that eurytopic animals can be very important for interpreting past human landscapes.
- 4 The analogical relationship can be abrogated in cases where animals displayed elastic preferences by exhibiting a broad tolerance to changing conditions through time.

Many years ago, Grayson (1981) cautioned zooarchaeologists that using archaeological vertebrates to reconstruct paleoenvironments is not a straightforward exercise. He warned against trusting any interpretation that treated identified taxa as variables; the results would always be in question because variations of taxonomic abundance in the sample could not be validly associated with fluctuations in the target of interest. The exact relationship between both the specimen counts and the number of animals that originally contributed to the sample, and the accumulated sample and the target of interest, is usually unknown and indeed unknowable. The numbers of animals reaching the area of assemblage deposition more likely reflect the mechanisms that accumulated them rather than their actual past

abundance, and because these mechanisms are rarely understood, the relationship between sample and target is usually never known with any precision.

Since the exact significance of taxonomic abundances is difficult to determine, Grayson (1981) cogently recognized that interpretations based on presence/absence data are the only currently acceptable approach to paleoenvironmental analysis. Interpretations based upon quantitative assessments have a greater chance of being incorrect. An asymmetrical interpretation of attribute level data, which emphasizes presence rather than absence, reduces these chances greatly. This approach is certainly not without its limitations for the reasons outlined by Findley (1964), problems with archaeological resolution, and the potential transport of animals from areas far beyond the depositional environment of interest (Grayson 1981: 35–36). However, problems associated with these issues are mitigated by reconstructing communities of associated vertebrates because the niche of an entire community is narrower than that of any one of its individual components. Problems associated with archaeological resolution and transport are also overcome through multiple concordance within an identified suite of taxa. The possibility that any of these problems had affected only one member of the community is far greater than the possibility that all members of the entire community were affected in the same direction and to the same magnitude (Birks and Birks 1980: 27; Grayson 1981: 35). The validity of our inferences can be further corroborated through concordance with other kinds of data, such as associated botanical specimens and archaeological context.

AN ARCHAEOLOGICAL EXAMPLE: ARCHAEOFAUNAL ACCUMULATION IN WESTERN EQUADOR

A zooarchaeological reconstruction of past landscape conditions that attempts to account for many of the issues discussed in this essay is provided in the analysis of a prehistoric pit from the tropical lowlands of western Ecuador (Stahl 2000). Pit features tend to be highly valued by archaeologists for many reasons, not least of which are the high resolution contexts they can provide for paleoecological inference. In particular, highly visible stratigraphy within pit features can augment our ability to interpret the elapsed time, nature, and even purpose of assemblage accumulation. The specimens associated with the pit consist of the discarded remnants of dietary animals and potentially entrapped faunas. The pit contexts enable the archaeologist to infer alternate pathways of assemblage accumulation, which permit further exploration of how these specimens might be used as proxies for understanding local landscape conditions in and around the original area of deposition. The validity of any interpretation about past landscape conditions can be explored further and potentially corroborated if other kinds of associated materials that preserved in the pit feature appear to support similar inferences.

Feature 5 is the surviving half of a large pit feature that was exposed in the left cut bank of the Río Pechichal, a tributary of the Río Jama, whose drainage basin is the largest of its kind in the northern Manabí province of western Ecuador (Fig. 7.2). It is one of a number of earthen features found at the site of Pechichal, a larger secondary multicomponent prehistoric center located in an alluvial pocket on the valley floor. The pit, with its restricted orifice and almost symmetrical outslipping walls, was excavated into a thick layer of compact volcanic tephra which was likely deposited by an eruption in the Andes between AD 300 and 500. Two radiocarbon samples retrieved from deep within the pit clearly place its oldest fill within the Muchique 2 Phase of the prehistoric Jama-Coaque culture between AD 400 and AD 750.

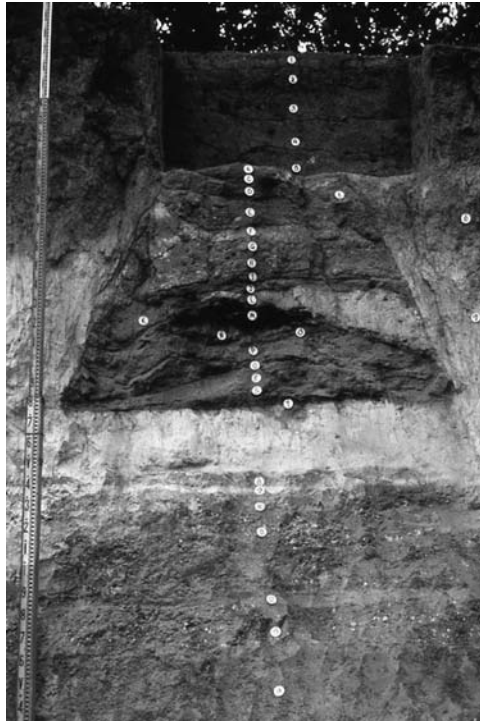


Figure 7.2 One half of the Feature 5 pit exposed in the cut bank of the Río Pechichal, Manabí Province, Ecuador. Photograph courtesy of James A. Zeidler.

Twenty clearly defined depositional strata are visible in the profile, which was used as a guide for excavation (Fig. 7.3). Pollen and phytolith samples were removed from the cleaned profile face, and the top of the pit was exposed through excavation of a 1.5×1.5 m test unit over its orifice. The matrix of each depositional stratum (contexts 25–29 and 34–48) was processed through a water flotation system equipped with a fine mesh barrel insert, and then sorted. The pit has an opening large enough to accommodate a human, and its recovered contents are consistent with discarded refuse, suggesting that it was originally used for storage and later for trash disposal. In addition to vertebrate specimens, its contents also included shell, burned clay and wattle and daub fragments, and various kinds of ceramic and lithic items. A sampled phytolith assemblage included evidence for grasses, a possibly cultivated root crop, trees, shrubs, and sporges. Macrobotanical contents included grasses, wood charcoal, maize, beans, wild legumes, cotton, amaranth, guava, edible nightshade, chirimoya, squash, nut, palm, edible herbs, fruits, pits, and tubers (Pearsall 2004).

The stratigraphic distribution of pit contents is variable and coincides with the uneven distribution of matrix volumes, the bulkiest of which are located toward the bottom of the pit. The assemblage of vertebrate specimens appears, however, to be vertically distributed into two distinct groups, including: (1) stratigraphic concentrations of skeletal specimens from smaller animals that occur in high frequencies, representing many different kinds of elements, and from many individuals (Fig. 7.4); and (2) stratigraphically dispersed and isolated skeletal specimens from larger animals that occur in lower frequencies, representing fewer different kinds of elements, and from fewer individuals. These observations can be combined with data from field research on neotropical forest fragmentation and ecological

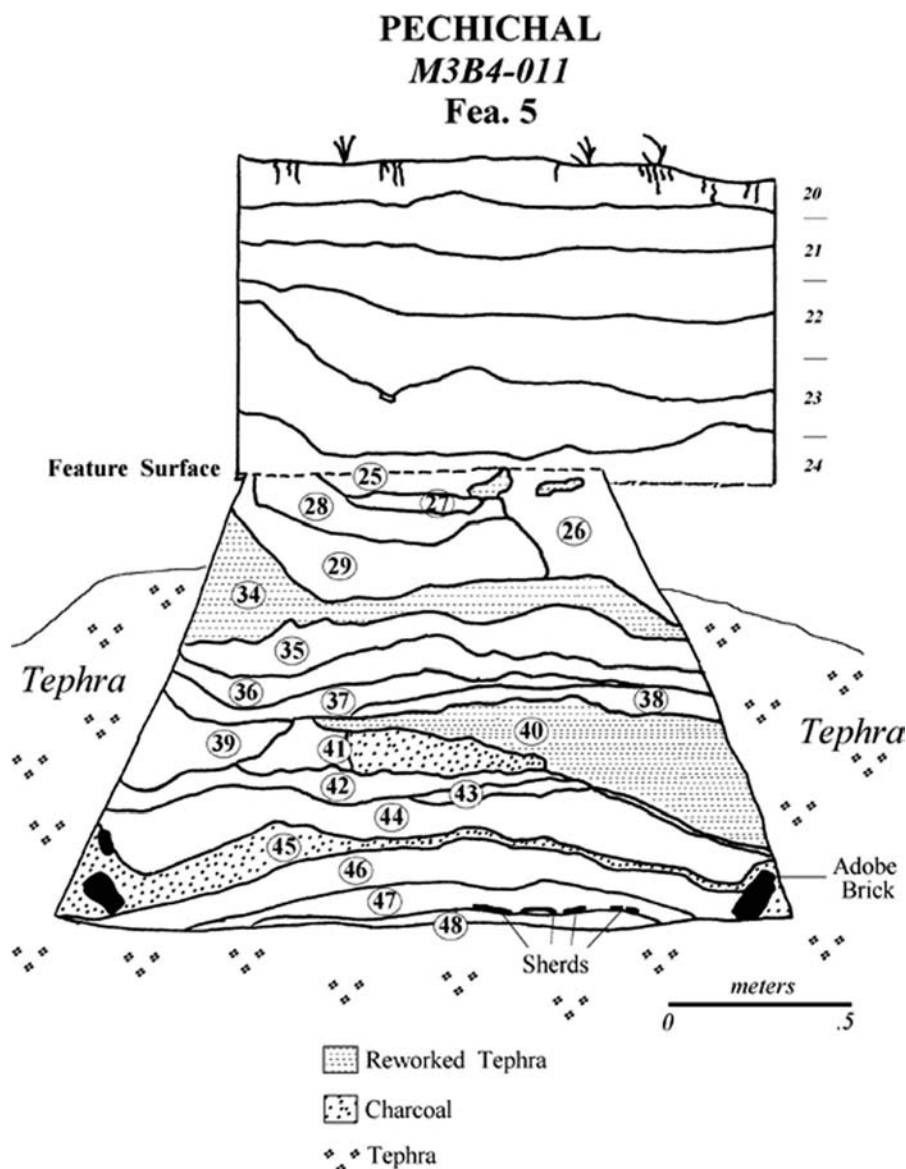


Figure 7.3 Accompanying stratigraphic profile of the Feature 5 pit showing depositional strata within the pit, and excavation strata in the superpositioned test unit.

information from represented species to provide powerful inferences about past landscape conditions.

The stratigraphically concentrated specimens likely include a mix of discarded food waste and naturally entrapped animals. Aquatic faunas, including thermally altered marine shells, river shrimp exoskeletons, and fish bones are found mostly in the lowest units of the pit. They appear in association with the remains of important food crops like maize, cotton, tubers, beans, palm, squash, and guava. Much of the thermally altered material in the pit is found in the lowest contexts, and it is suggested that garbage was burned *in situ*



Figure 7.4 Rodent bones and teeth recovered from Feature 5 through water flotation.

as a factor of waste disposal. In addition, the relatively complete skeletons of small animals suggest that certain faunas living in the vicinity of the pit may have accidentally fallen into an outwardly sloping pit and subsequently died. In particular the lowest deposits, from which escape was least likely for a small animal, include numerous specimens from different elements of frogs or toads, and many snake vertebrae. Snakes are heavily represented in the assemblage by vertebral fragments, as these preserved specimens are the only ones available for identification. There are also three conspicuous concentrations of rodent specimens, most of which represent the preserved remains of very small rats and mice. Many of these smaller skeletons are relatively complete, some have the glossy appearance of intrusive specimens, and all appear in association with botanical food waste (Fig. 7.4). Rotting garbage and/or insects may have attracted these animals to the pit, after which they may have fallen in during periodic episodes of waste disposal and become entrapped by the insloping (from their perspective) walls.

The stratigraphically dispersed mammalian specimens within the pit, with the exception of a few bat teeth, represent the remains of important food animals. Skeletal representation is characterized by relatively few specimens, of few skeletal elements, and from few individual animals that are dispersed throughout the pit profile as isolated fragments. Most of the taxa represented in this sample are animals not prone to entrapment, and include favored dietary sources like larger opossum, monkeys, rabbits, agoutis, peccary, and deer. Nevertheless, for the purposes of landscape interpretation, establishing a precise mechanism for how portions of these animals got into the pit is less important than the fact that they were recovered in close association with the concentrations of smaller, potentially entrapped, animals.

Archaeological context facilitated the identification of two distinct vertical groupings of archaeofaunal specimens which had likely accumulated in the pit in different ways. When the natural histories of contemporary mammalian analogs for the pit faunas are considered alongside these dissimilar accumulation histories, this particular association of preserved archaeological specimens makes ecological sense. The likely entrapped faunas include a superabundance of hardy generalists that prevail along forest edges, whereas the dietary faunas consist of animals that thrive either along the edge or within the backdrop of forest

fragments. It is reasonable to suggest that the Pechichal pit assemblage had accumulated in a landscape context characterized by significant forest fragmentation.

The inference is generated on the basis of observations by ecologists who wish to assess the effects of fragmentation on tropical forest ecosystems and how these data can be applied to issues of forest conservation and management. Like most ecological phenomena, the effects of fragmentation are certainly complex and interrelated; however, these ecological studies also document which vertebrate taxa are able to thrive under such conditions and why. Particularly abundant are many smaller herpetofaunas and rodents, especially habitat generalists and those with insectivorous diets. It is not surprising that the pit assemblage is numerically dominated by small rodents that favor clearings and secondary groundcover, especially in and around the kinds of landscapes created by and for humans. The assumption is that many of these entrapped faunas lived and died within the immediate environs of the pit, and archaeological evidence indicates that the feature was situated in the cleared area of human habitation.

It is interesting to note that the stratigraphically dispersed faunas, which consist of larger and presumably dietary taxa, tend to be habitat generalists that thrive under conditions of forest fragmentation, a point about which tropical horticulturists are intimately aware. The associated botanical specimens clearly indicate a suite of both wild and domesticated plants that is typical of the polycultural horticulture practiced in tropical regions. The isolated specimens of larger pit faunas include birds and mammals that are minimally capable of persisting in forest fragments, and under certain conditions actually thrive there due to their diets, habits, flexibility, and/or foraging range. Through analysis of the pit archaeofaunas, and corroboration with associated archaeological materials and context, it is hypothesized that the Pechichal Feature 5 contents originally accumulated in an open pit situated in or near a secondary edge which was backed by fragmented isolates of remnant forests. The inference supports a broader argument that the prehistoric environment of the Jama valley was heavily anthropogenic, perhaps since human farmers colonized the valley over four millennia ago (Pearsall 2004; Stahl 2006).

SUMMARY AND DISCUSSION

This chapter began with a number of interrelated questions which embrace ethnobiological pursuits and whose answers hold significant consequences for contemporary society. They raise many wide-ranging practical and moral implications in the matter of how humans have interacted with other organisms. The archaeobiological reconstruction from the Jama Valley of western Ecuador illustrates a type of tropical agroforestry which was likely integrated with other forms of forest cultivation into an intensively managed pre-Columbian landscape (Denevan 2001: 124; 2006). Ethnobiologists study Indigenous management systems among tropical farmers today; however, in most parts of the western hemisphere archaeobiological data provide the only available information for understanding these questions in past contexts. Their answers contribute to the interests of a broader research program in historical ecology and inform on the logic of an Indigenous knowledge that was once implemented to create and manage resources by and for humans (Stahl 2008b). These various forms of ethnobiological inquiry hold direct applications and significant implications for contemporary resource management.

Relic human landscapes can be accessed through the analysis of faunal specimens recovered from archaeological contexts. The sample assemblage of preserved specimens often comprises two subsets of material which can be set apart from each other by their

different accumulation histories. Both can be of importance for understanding past human landscapes; however, it is important to assess critically how the analyzed sample reflects the target of interest. This helps us to gauge whether our data are appropriate for the research questions we wish to answer. We can evaluate the relationship between our sample and the target assemblage of interest through the use of inferential logic and the analysis of preserved evidence and its associated archaeological context. Preserved clues that pertain to aspects of archaeological recovery, specimen identification, perimortem accumulation and deposition, and postmortem accumulation, dispersal, and destruction are evaluated alongside the omnipresent issue of equifinality. The interpretations we generate are less prone to error when we consider our archaeofaunal assemblage as ecologically parsimonious suites of attributes that are positively identified in association with their spatial and temporal contexts of interest.

Zooarchaeology has experienced significant methodological headway over the past few decades and has departed considerably from previously accepted standards of archaeological interpretation. These strides have been achieved primarily through the application of more nuanced taphonomic approaches to an understanding of assemblage formation. This in turn relies heavily on the continued contribution of new methodological instruments which are added through actualistic research to the growing toolkit used by zooarchaeologists. Future investments of intellectual energy should continue to increase the size, scope, and precision of our taphonomic toolkit, which will further enhance our critical assessments of assemblage formation, and our ability to interpret the extent and nature of anthropogenic involvement in past landscapes.

REFERENCES

- ANDREWS P. *Owls, caves and fossils*. Chicago: University of Chicago Press; 1990.
- ANDREWS P, EVANS EMN. Small mammal bone accumulations produced by mammalian carnivores. *Paleobiology* 1983; 9:289–307.
- BALÉE W. *Footprints of the forest: Ka'apor ethnobotany—the historical ecology of plant utilization by an Amazonian people*. New York: Columbia University Press; 1994.
- BALÉE W. Historical ecology: premises and postulates. In: BALÉE W, editor. *Advances in historical ecology*. New York: Columbia University Press; 1998; p 13–29.
- BALÉE W. The research program of historical ecology. *Annu Rev Anthropol* 2006;35:75–98.
- BALÉE W, ERICKSON CL. Time, complexity, and historical ecology. In: BALÉE W, ERICKSON CL, editors. *Time and complexity in historical ecology*. New York: Columbia University Press; 2006. p 1–17.
- BEHRENSMEYER AK. The taphonomy and paleoecology of Plio-Pleistocene vertebrate assemblages east of Lake Rudolf, Kenya. *Bull Mus Comp Zool* 1975;146:473–578.
- BINFORD LR. *Nunamiut ethnoarchaeology*. New York: Academic Press; 1978.
- BINFORD LR. *Bones. Ancient men and modern myths*. New York: Academic Press; 1981.
- BIRKS HJB, BIRKS HH. *Quaternary Palaeoecology*. Baltimore (MD): University Park Press; 1980.
- BUTLER VL, SCHROEDER RA. Do digestive processes leave diagnostic traces on fish bones? *J Archaeol Sci* 1998; 25:957–971.
- BRAIN CK. *The hunters or the hunted? An introduction to African cave taphonomy*. Chicago (IL): University of Chicago Press; 1981.
- CLARKE J, KIETZKE KK. Paleoecology of the lower nodule zone, Brule formation in the big badlands of South Dakota. *Fieldiana Geol Mem* 1967;5:111–129.
- CRANDALL BD, STAHL PW. Human digestive effects on a micromammalian skeleton. *J Archaeol Sci* 1995; 22:789–797.
- CRUMLEY CL. Historical ecology: a multidimensional ecological orientation. In: CRUMLEY CL, editor. *Historical ecology: cultural knowledge and changing landscapes*. Santa Fe (NM): School of American Research Press; 1994. p 1–16.
- DENEVAN WL. *Cultivated landscapes of native Amazonia and the Andes*. Oxford: Oxford University Press; 2001.
- DENEVAN WL. Pre-European forest cultivation in Amazonia. In: BALÉE W, ERICKSON CL, editors. *Time and complexity in historical ecology*. New York: Columbia University Press; 2006. p 153–163.
- DODSON P. The significance of small bones in paleoecological interpretation. *Univ Wyoming Contrib Geol* 1973; 12:15–19.
- DRIVER JC. Identification, classification and zooarchaeology. *Circaea* 1992; 9:35–47.
- ERICKSON CL. The domesticated landscapes of the Bolivian Amazon. In: BALÉE W, ERICKSON CL, editors. *Time and complexity in historical ecology*. New York: Columbia University Press; 2006. p 235–278.

- ERICKSON CL. Amazonia: the historical ecology of a domesticated landscape. In: SILVERMAN H, ISBELL WH, editors. *Handbook of South American archaeology*. New York: Springer; 2008. p 157–183.
- FINDLEY JS. Paleoeologic reconstructions: vertebrate limitations. In: HESTER JJ, SCHOENWETTER J, editors. *The reconstruction of past environments. Proceedings of the Fort Burgwin Conference on Paleoeology; 1962 (nr 3)*. Fort Burgwin (NM): Fort Burgwin Research Center; 1964. p 23–25.
- GRAYSON DK. A critical view of the use of archaeological vertebrates in paleoenvironmental reconstruction. *J Ethnobiol* 1981;1:28–38.
- HEDGES REM. Bone diagenesis: an overview of processes. *Archaeometry* 2002;44:319–328.
- HILL AP. Butchery and natural disarticulation: an investigatory technique. *Am Antiq* 1979;44:739–744.
- JANZEN D. Gardenification of wildland nature and the human footprint. *Science* 1998;279:1312–1313.
- LAM YM, PEARSON OM. The fallibility of bone density values and their use in archaeological analyses. *J Taphon* 2004; 2:99–115.
- LYMAN RL. Zooarchaeology and taphonomy: a general consideration. *J Ethnobiol* 1987a;7:93–117.
- LYMAN RL. Archaeofaunas and butchery studies: a taphonomic perspective. In: SCHIFFER MB, editor. *Advances in archaeological method and theory*. Volume 10. San Diego (CA): Academic Press; 1987b. p 249–337.
- LYMAN RL. *Vertebrate taphonomy*. Cambridge: Cambridge University Press; 1994.
- LYMAN RL, FOX GL. A critical evaluation of bone weathering as an indication of bone assemblage formation. *J Archaeol Sci* 1989;16:293–317.
- PEARSALL DM. *Plants and people in ancient Ecuador: the ethnobotany of the Jama River Valley*. Belmont (CA): Wadsworth/Thomson Learning; 2004.
- SHAFFER BS. Quarter-inch screening: understanding biases in recovery of vertebrate faunal remains. *Am Antiq* 1992; 57:129–136.
- SHAFFER BS, SANCHEZ JLJ. Comparison of 1/8"- and 1/4"-mesh recovery of controlled samples of small-to-medium-sized mammals. *Am Antiq* 1994;59:525–530.
- SHIPMAN P. *Life history of a fossil. An introduction to taphonomy and paleoecology*. Cambridge (MA): Harvard University Press; 1981.
- SHIPMAN P, FOSTER G, SCHOENINGER M. Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. *J Archaeol Sci* 1984; 11:307–325.
- STAHL PW. The recovery and interpretation of microvertebrate bone assemblages from archaeological contexts. *J Archaeol Method Theory* 1996; 3:31–75.
- STAHL PW. Archaeofaunal accumulation, fragmented forests, and anthropogenic landscape mosaics in the tropical lowlands of prehispanic Ecuador. *Lat Am Antiq* 2000; 11:241–257.
- STAHL PW. Microvertebrate synecology and anthropogenic footprints in the forested neotropics. In: BALÉE W, ERICKSON CL, editors. *Time and complexity in historical ecology*. New York: Columbia University Press; 2006. p 127–149.
- STAHL PW. Vertebrate analysis. In: PEARSALL DM, editor. *Encyclopedia of archaeology*. Volume 3. New York: Academic Press; 2008a. p 2173–2180.
- STAHL PW. The contributions of zooarchaeology to historical ecology in the Neotropics. 2008b. *Quatern Int* 2008b; 180:5–16.
- THOMAS DH. Great Basin hunting patterns: a quantitative method for treating faunal remains. *Am Antiq* 1969; 34:393–401.
- VOORHIES M. Taphonomy and population dynamics of an early Pliocene vertebrate fauna, Knox County, Nebraska. *Contributions to Geology Special Paper nr 1*. Laramie: University of Wyoming; 1969.
- WATSON JPN. Fragmentation analysis of animal bone samples from archaeological sites. *Archaeometry* 1972; 14:221–227.
- WATSON JPN. The estimations of the relative frequencies of mammalian species: Khirokitia, 1972. *J Archaeol Sci* 1979;6:127–137.
- WHYTE TR. Small animal remains in archaeological pit features. In: PURDUE JR, KLIPPEL WE, STYLES BW, editors. *Beamers, bobwhites, and bluepoints. Tributes to the career of Paul W. Parmalee*. Illinois State Museum Scientific Papers 23. Springfield: Illinois State Museum; 1991. p 163–176.
- WILSON MVH. Taphonomic processes: information loss and information gain. *Geosci Can* 1988;15: 131–148.

Chapter 8

Ethnobiology as a Bridge between Science and Ethics: An Applied Paleozoological Perspective

STEVE WOLVERTON

Department of Geography, Center for Environmental Archaeology, Institute of Applied Sciences, University of North Texas, Denton, TX

CHARLES R. RANDKLEV

Department of Biology, Institute of Applied Sciences, University of North Texas, Denton, TX

ANDREW BARKER

Department of Geography, Center for Environmental Archaeology, Institute of Applied Sciences, University of North Texas, Denton, TX

APPLIED PALEOZOOLOGY	117
SCALES FOR RESTORATION AND CONSERVATION	117
ANALYTICAL METHODS	118
WHITE-TAILED DEER OVERABUNDANCE IN CENTRAL TEXAS	119
BLACK BEARS IN MISSOURI	121
LATE HOLOCENE FRESHWATER MUSSEL BIOGEOGRAPHY IN NORTH TEXAS	124
THE BIOGEOGRAPHIC POTENTIAL OF ARCHAEOLOGICAL ORGANIC RESIDUES	126
DISCUSSION	127
CONCLUSION	129
ACKNOWLEDGMENTS	129
REFERENCES	129

In the face of the global environmental crisis, ethnobiologists find themselves in a potentially helpful position. Ethnobiology represents one of a few bridging disciplines between the philosophical foundations of environmental ethics and the scientific foundations of

environmental science. Environmental philosophers study what ought to be done to address environmental problems at multiple spatial and temporal scales (Borgerhoff-Mulder and Coppolillo 2005; Rolston 1988), focusing on what it means to value nature, how humans do value and should go about valuing nature, and how these ethical footings should inform science and policy. Environmental science incorporates functional roles for many scientific disciplines (Miller 2007). Environmental science and environmental ethics share the goal of curbing the environmental crisis through communication among practitioners from different fields, appreciation of diverse perspectives, and incorporation of vested parties in policies and management decisions (Penn and Mysterud 2007a). Practitioners of ethnobiology communicate and interact across disciplinary, cultural, and temporal boundaries (Lepofsky 2009; Nabhan 2009). Within ethnobiology, applied zooarchaeology (or “applied paleozoology” to include paleontology)—the study of animal remains from archaeological and paleontological sites to provide baseline information relevant to restoration ecology and conservation biology—transcends temporal boundaries and offers an example of a bridging perspective that links ethics to science.

Many of the disciplines represented within ethnobiology offer a perspective of what philosopher Albert Borgmann (2000) terms “disclosure,” a shift in analytical scale such that natural processes (e.g., geological, cultural, and/or biological processes) are more profoundly understood. Examples are cultural relativism¹ in cultural anthropology, the theory of evolution in biology, and deep temporal perspectives in geology and archaeology. Applied anthropologists, for example, mediate between people of radically different cultural backgrounds, the goal being to accomplish the “profounder task” of compromise that values multiple cultural perspectives but also meets people’s needs through processes such as cultural brokerage and social marketing (Van Willigen 2002).

The deep temporal perspective of the time-like sciences (Dunnell 1982) such as geology, evolutionary biology, and archaeology transcends the analytical scale of a human lifetime



Figure 8.1 A conceptual framework of the interaction between the environmental–ecological sciences and environmental ethics, highlighting ethnobiology as a bridging discipline. After Rozzi 1999: 912, Figure 1. Copyright, American Institute of Biological Sciences.

¹Here we mean “descriptive relativism” characterized by Brown (2008: 367), but we acknowledge that this term entails a range of meanings spanning from cognitive anthropology to ethics.

and provides awareness of the contingency of modern phenomena (Oelschlaeger 2000; Simpson 1963). Without this depth, modern solutions to seemingly short-term problems are divorced from evolutionary reality. From a perspective of disclosure, applied paleozoology is highly relevant to conservation biology and restoration ecology. It bridges between environmental science and philosophy (Fig. 8.1). Without such a perspective, the paths to extinction, reduction in biodiversity, and introduction of pest exotic species today are analyzed without understanding the “journey” to the “destination.” Applied paleozoology bridges ethics and science by offering a sense of contingency and urgency because consideration of deep time highlights the environmental crisis by providing a basis for concluding that modern humans *ought* to make changes to reverse the long-term effects of unsustainable environmental policies and habits.

APPLIED PALEOZOLOGY

Applied paleozoology is the use of zooarchaeological/paleontological datasets to provide long-term information on biological changes (Lyman 1996). What species were present in an area in the past (Grayson 2006)? What species should not be there today (Emslie 1987)? How has biodiversity changed in the face of modern human impacts (Stahl 1996)? What are the long-term evolutionary and ecological implications of human impacts on the environment (Russell 2003)? Applied paleozoology offers new answers to important questions and a new perspective on the evolutionary trajectories of ecosystems (Landres 1992). For example, Virginia Butler and Michael Delacorte (2004) studied Holocene paleozoology of threatened and endangered fish species in the Owens River Valley of California. They found that the proposed construction of several wetland and stream preserves may not be the solution for impacts on native fish species, thought to relate to overuse of the Owens River water supply by Los Angeles and other urban areas. The threatened fish species had survived extended periods of low water (droughts) in the past (e.g., the mid-Holocene Altitheermal climate interval), and a greater threat seems to be the more recent introduction of competitors and predators rather than reduction in habitat availability. In this case, the financial cost of constructing and maintaining preserves might result in economic waste. Similarly, there has been extensive debate regarding the status of mountain goats (*Oreamos americanus*) in the Olympic National Park, Washington (Lyman 1998). Park officials were considering the extermination of mountain goats in the park because, based on historical documentation, they thought the goats were exotic. R. Lee Lyman has argued in several publications that the park did not survey the paleozoological record to determine whether or not mountain goats were there in the past; the historical record supports only ambiguous interpretations as to whether or not mountain goats are exotic. These examples and many others (Frazier 2007; Graham 1988; edited volumes by Lyman and Cannon 2004; Penn and Mysterud 2007b; Rick and Erlandson 2008) highlight the importance of temporal scale. Which scale is relevant for conservation biology and restoration ecology?

SCALES FOR RESTORATION AND CONSERVATION

There has been much debate as to which temporal and spatial scales are appropriate for restoration (Hunter 1996); we focus on temporal scales, which are relevant from a paleozoological perspective. At issue is the question: what should impacted environments be

restored/conserved to? J. Baird Callicott (2002) outlines three scales from which to choose for determining benchmarks for restoration and/or conservation. The microscale is the scale of a human lifetime or shorter, and it is inappropriate because many human impacts are longer term. The macroscale is the scale of evolutionary/geological time of tens of thousands to millions to billions of years ago. This scale is also inappropriate because at the evolutionary timescale ecological communities, species, and landscapes change in irreversible ways. At this scale phenomena are always in a state of becoming something else. An example of a restoration effort that ignored a paleozoological perspective and mistakenly (unknowingly) based restoration on an evolutionary benchmark was the failed reintroduction of sea otters (*Enhydra lutris*) to the Oregon Coast (Lyman 1988; Valentine et al. 2008). The reintroduced individuals were from an Alaskan sub-population. Paleozoological research highlights that a morphological and genetic cline existed along the coast and that late Holocene Oregon Coast sea otters were a different ecotype than the source population for modern reintroduction. The reintroduced individuals do not appear to have been adapted to the Oregon Coast, which represents an evolutionary scale difference.

Callicott argues that an intermediate scale, the mesoscale, is most appropriate for restoration and/or conservation. This is the scale at which ecological phenomena change. He argues that such change occurs in centuries and millennia. Previous perspectives on benchmarks have been loosely ethnocentric in that pre-1492 conditions in North America (prior to European arrival in the New World) were considered pristine environments. This perspective ignored the fact that humans existed in the New World for at least 14,000 years. On the other hand, the opposite extreme has been adopted, that all human societies create “anthropogenic landscapes.” Some proponents of this perspective suggest that late Pleistocene humans in the New World caused the extinctions of many genera of animals (Martin 1973). They argue that analog species from other parts of the world, which represent “the closest living species” (such as elephants, African lions), should be introduced into North American Pleistocene parks (Donlan et al. 2005). This perspective is inappropriate for a number of reasons. First, if Rozzi (1999) is correct in asserting that a primary cause of the current environmental crisis is that humans are increasingly divorced from nature, the notion that all human impacts universally create anthropogenic landscapes supports that divorce. Second, there is very little to no archaeological evidence that humans caused the late Pleistocene extinctions (Grayson and Meltzer 2003; Hill et al. 2008; Wolverson et al. 2009a), yet the presumption that such was the case is a “poster child” for the anthropogenic landscape perspective (Penn and Mysterud 2007a). Finally, this perspective ignores Callicott’s warning that *because evolution occurs* the evolutionary time-frame is inappropriate for restoration and conservation. Introduction of distantly related “closest living species” might promote an ecological disaster of unimagined “anthropogenic” proportion in a North American environment that has changed substantially during the Holocene (Rubenstein et al. 2006). We agree with Callicott that the mesoscale is most appropriate for conservation biology and restoration ecology.

ANALYTICAL METHODS

We present case studies of our own research, not because they represent better examples of applied paleozoology than other studies, but because these are the examples with which we are most familiar. Paleozoological data are analyzed at nominal (presence/absence) and/or ordinal (rank order) scale using non-parametric statistics, such as Mann–Whitney *U* tests to assess sample differences. This statistical approach avoids assumptions of normality because

paleozoological populations cannot be directly examined nor can they (often) be resampled. It also acknowledges that quantitative paleozoological data are estimates of actual abundances² based on counts of remains that passed through taphonomic histories (Grayson 1984; Lyman 2008).

White-tailed Deer Overabundance in Central Texas

During most of the Holocene (the last 10,000 years) humans and other large mammalian predators (e.g., black bears [*Ursus americanus*], wolves [*Canis lupus*], pumas [*Puma concolor*], and even jaguars [*Panthera onca*]) roamed Texas. White-tailed deer (*Odocoileus virginianus*) represented a common prey resource for these predators during that time. Wildlife biology studies show that in the absence of predation, deer populations explode to extremely high densities (Kie et al. 1983; Simard et al. 2008). White-tailed deer and other ungulates exhibit an interesting adaptation when their population densities are high for extended periods of time (e.g., decades); their body size becomes smaller (Geist 1998; Wolverson 2008a). This response is the result of phenotypic plasticity, which represents an adjustment to short-term environmental changes in food supply without much genetic change. At high population densities, food-available-per-animal declines. An energetic compromise is smaller size (Wolverson et al. 2009b). Native American human hunters and large carnivores no longer exist in Texas, and central Texas is thought to have one of the highest regional white-tailed deer population densities in North America (Teer 1984; Walton 1999). Large native predators were exterminated in Texas to protect ranching interests during the last two centuries, and there are no federally recognized Native American tribal lands in the state. With impacts of pest-level white-tailed deer populations, fire protection (which has disturbed the natural regime), and livestock ranching combined, much of central Texas is currently witnessing ecosystem decay. This is happening in part because over-browsing of native deciduous trees, saplings, and seedlings has given the water-competitive, highly flammable, unpalatable (to deer and livestock) juniper (*Juniperus ashei*) a competitive advantage throughout the region, essentially producing juniper monocultures in many areas (Russell and Fowler 1999, 2004). Central Texas, especially near Austin and San Antonio and in areas to the west of those cities, is a food-poor anthropogenic landscape for the white-tailed deer, which was shaped during the last two centuries. Given that population densities of white-tailed deer are very high in this region and that habitat quality is poor, we expect that the size of deer from Holocene archaeological and paleontological sites from central Texas should be significantly larger than that of modern deer.

To compare modern and prehistoric deer, we measured the astragalus (ankle bone) of white-tailed deer (Fig. 8.2). The astragalus matures early in life and is likely to reflect differences in adult body size (Purdue 1987). Astragalus size among mid- to late Holocene deer from central Texas is significantly larger than among modern *unhunted* deer from the same region (Table 8.1; Fig. 8.3a). But the size of prehistoric deer cannot be distinguished from a modern population that has been systematically sport-harvested in central Texas for the last 50 years (Table 8.1; Fig. 8.3b). Climate change during the mid- to late Holocene, coming out of the dry and warm Altithermal, likely resulted in a higher quality habitat through time (Ferring 1995), which should not—by itself—have made for smaller deer. A potential concern is that prehistoric deer astragali have not been identified to sex. It is unlikely, however,

²“Actual abundances” can mean several things; paleozoological assemblages pass through histories typically conceived of as a series of assemblages. The “life assemblage” or “biocoenose,” which represents the past living community, is the target variable we are referring to here (see Lyman 2008: 21–26 for discussion).

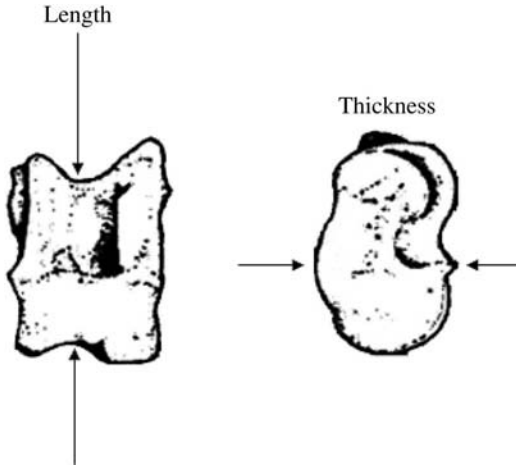


Figure 8.2 Measurements taken on white-tailed deer astragali. Measurements from Purdue (1987:3, Figure 1).

that the difference in size between the modern and prehistoric deer is the result of differing sex ratios. The prehistoric sample comprises roughly the same level of size variability as the modern sample, which contains bucks and does (Table 8.1). A size distribution with bucks and does in equivalent numbers is slightly bimodal and symmetrical. A difference in skewness from symmetry between the two samples would suggest a difference in sex ratio. Pearson’s skewness of 0 represents perfect symmetry and that of ± 0.6 or greater

Table 8.1a Descriptive Statistics Measurements of White-Tailed Deer Astragali, mm^a

Sample	n	Median	Mean	Standard deviation	CV (%)	Pearson’s skewness
Paleozoological						
Length	58	29.85	29.88	1.41	4.73	0.06
Thickness	58	21.30	21.33	1.15	5.39	0.08
Modern unhunted						
Length	29	28.68	28.63	1.18	4.12	-0.13
Thickness	29	20.00	19.88	1.00	5.02	-0.36
Modern hunted						
Length	43	30.06	29.95	1.36	4.53	-0.24
Thickness	43	21.23	21.06	1.15	5.47	-0.44

Table 8.1b Mann–Whitney *U* Comparisons for White-Tailed Deer Samples

Test	<i>U</i> -statistic	p-value
Paleo versus unhunted		
Length	440.0	p < 0.001
Thickness	285.5	p < 0.001
Paleo versus hunted		
Length	1207.5	0.786
Thickness	1092.0	0.287

^aAfter Wolverton et al. 2007: 549.

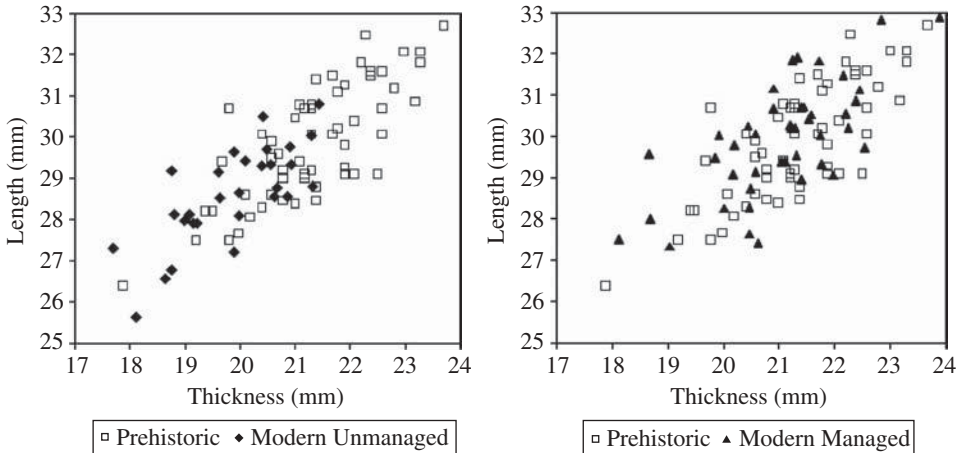


Figure 8.3 Bivariate scatter diagram of white-tailed deer astragalus size: (a) comparing un hunted modern deer to Holocene paleozoological deer from central Texas and (b) comparing hunted modern deer to the same paleozoological assemblage. Related descriptive and inferential statistics are in Table 8.1. Used with kind permission from Springer Science+Business Media: Environmental Management, Vol. 39 (2007), p. 549, Wolverton et al., Figures 3 and 4.

represents significant skewness (Hildebrand 1986). Neither sample is skewed, suggesting that both representatively sample bucks and does (Table 8.1). It is possible that the size difference between modern-unhunted and prehistoric deer represents evolutionary change, but this is unlikely given that white-tailed deer are known to be very phenotypically plastic in terms of body size and given that the Fort Hood deer population dramatically increased in size during the mid-twentieth century as systematic harvesting progressed annually (Fig. 8.4). Fort Hood deer in the mid-twentieth century were similar in size to deer from areas that are overcrowded in central Texas today, but they became larger in size with the thinning effects of systematic managed sport harvest.

The broader implication of this case study is that the “deer problem” is common in parts of North America as deer reach pest population levels, and its effects range from crop damage to increases in automobile accidents (Côté et al. 2004). It is difficult for local municipalities to address the problem without reducing population density through culling. Translocating deer to other areas is expensive, as is sterilization; culling, however, is often an unpopular solution, because many people view killing wild animals as unethical (Rolston 1988). The paleozoological perspective in central Texas can provide a disclosive point of view through the lens of deep time (Wolverton et al. 2007). Given this disclosure, it may be ethical to thin populations through managed harvest or predator restoration.

Black Bears in Missouri

By 1900 black bears (*Ursus americanus*) were extirpated from Missouri (Schwartz and Schwartz 2001); bears were translocated from Minnesota into Arkansas during the mid-1900s (Smith and Clark 1994). The translocated population has grown and now ranges into southern Missouri. Very little is known regarding historical populations of black bears in the Midwest because they were eradicated by Euro-Americans during westward expansion and settlement. Bear remains were excavated from two natural trap caves—Lawson Cave and Jerry Long Cave—in central and eastern Missouri during the 1950s.

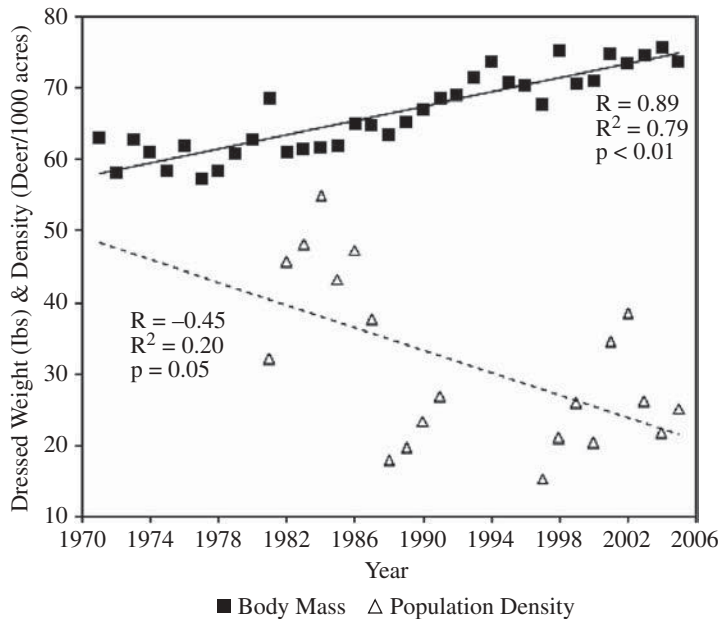


Figure 8.4 Mean field dressed weight (lb) increase in 1.5-year-old bucks at Fort Hood as systematic managed harvest became established and progressed from 1971 to 2005 (closed squares; solid line). A corresponding decrease in population density is recorded for much of the same period (open triangles; dashed line).

The caves are traps because they are deep vertical fissures into which animals fell but from which they could not escape (Wolverton 2006). Radiocarbon dates and associated artifacts indicate that the remains date to the historic period within the last 250 years before present (Wolverton 2001). The remains of 22 individuals were recovered from the caves, and these represent the largest record of Missouri black bears prior to extirpation.

The remains represent relatively large individuals, prompting speculation in the mid-1900s that the deposits were either late Pleistocene in age or that the remains approached the lower limit of grizzly bear size (Wells 1959). Neither of these is the case; instead, the size of the remains relates to age- and sex-specific behavioral characteristics that resulted in the entrapment of young males (Wolverton 2006). Figure 8.5a shows the age distribution of black bears from the caves; Figure 8.5b illustrates that tooth size of the natural trap bears overlaps with the upper half of a size distribution (the male half) from a modern sample. Tooth size of the natural trap bears significantly differs from that of modern females but cannot be distinguished from modern males (Table 8.2). This is of interest to modern wildlife biologists (see below).

Bears were attracted to the caves by carrion, and it is likely that individual bears entered in the search for food. Remains of cubs are uncommon (one individual is present) indicating that the individuals that fell into the traps were not attempting to establish dens. Other species represented in the fauna tend to be scavengers, such as pigs and turkey vultures (Wolverton 2008b). Why were young adult male black bears attracted to carrion in the caves, and not members of other age/sex classes?

Male bears enter a very stressful period at the onset of and during young adulthood (Bunnell and Tait 1981). They leave the company of their mothers and must establish territories in a matrix of territorial older males through competition for food and mates. Young adult males are known to venture more commonly into areas of human habitation to search for food (e.g., garbage); they are more likely to be drawn to and captured in

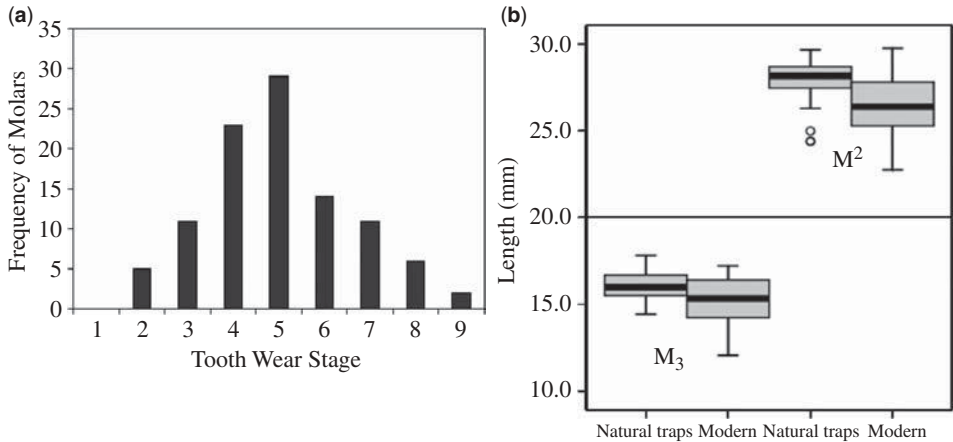


Figure 8.5 Tooth wear age structure (a) for historic-period black bear remains recovered from Lawson and Jerry Long caves in Missouri. Tooth size distributions (b) for modern Midwestern and Lawson/Jerry Long Cave black bears. Related descriptive and inferential statistics can be found in Table 8.2. Reprinted from *Ursus*, Vol. 19 (2008), p. 181, Figure 4.

baited traps and to perish in altercations with humans (e.g., automobile collisions) (Beckmann and Berger 2003; Garshelis and Pelton 1981). Although wildlife biologists know that young adult bears are vulnerable to accidental deaths, conflict with humans, and entrapment, it has not been established whether or not this pattern is a modern phenomenon produced by collapsing territory size or if it relates to life history adaptation in

Table 8.2a Descriptive and Inferential Statistics for Black Bear Tooth Measurements, mm^a

Source sample	n	Median	Mean	Standard deviation	CV (%)
Natural trap					
M ² length	21	28.20	27.75	1.54	5.6
M ² width	21	16.00	15.99	0.95	5.9
M ₃ length	18	16.20	16.09	1.09	6.8
M ₃ width	18	12.80	12.82	0.83	6.5
Modern					
M ² length	30 ^b	26.42	26.41	1.86	7.0
M ² width	30 ^b	15.88	15.95	1.35	8.5
M ₃ length	22	15.34	15.23	1.43	9.4
M ₃ width	22	12.61	12.38	1.46	11.8
Modern males					
M ² length	14	27.86	27.83	1.18	4.2
M ² width	14	17.51	17.02	0.91	5.4
M ₃ length	11	16.06	15.89	0.92	5.8
M ₃ width	11	13.19	13.21	1.11	8.4
Modern females					
M ² length	14 ^b	25.68	25.42	1.27	5.0
M ² width	14 ^b	15.31	15.20	0.88	5.8
M ₃ length	11 ^b	14.22	14.56	1.58	10.8
M ₃ width	11 ^b	11.81	11.55	1.30	11.3

Table 8.2b Mann–Whitney *U* Comparisons for Black Bear Samples

Test	<i>U</i> -statistic	p-value
Males versus natural traps		
M ² length	139.5	0.382
M ² width	65.5	<0.01
M ₃ length	110.0	0.827
M ₃ width	81.5	0.431
Females versus natural traps		
M ² length	38.5	<0.01
M ² width	71.0	0.01
M ₃ length	45.0	0.02
M ₃ width	46.0	0.02

^aAfter Wolverton 2008b: 182.

^bIncludes bears of unknown sex; those assigned to females were smaller than all known females.

bears. Indeed, habitat fragmentation/displacement by humans has greatly reduced the black bear's range during the last four centuries. Our data suggest that the vulnerability of young adult males to accidental deaths and their propensity for risky behavior relates not to modern impacts but to their behavioral ecology. Without the temporal perspective that paleozoology provides, this evolutionary cause of young adult bear mortality could not be determined. A shift in temporal scale reveals that young adult male bears pass through a selective filter that is quite natural and that wildlife managers should not seek to alter that pattern.

Late Holocene Freshwater Mussel Biogeography in North Texas

Freshwater mussels (unionids) have experienced a dramatic decline in numbers and distribution throughout the United States. It has been estimated that, of the 297 species in North America, 12% are extinct and 23% are threatened or endangered (Galbraith et al. 2008). Freshwater mussels possess biological characteristics that render them susceptible to range reductions and extirpations through habitat fragmentation (Vaughn and Taylor 1999). Unionids are long-lived, sedentary organisms that spend a portion of their lives as fish ectoparasites. As a result, anthropogenic impacts such as overharvesting, stream modifications, water quality deterioration, introduction of alien species, and apathetic land management policies have reduced many unionid populations (Bogan 1993; Lydeard et al. 2004). Unfortunately, the magnitude of these impacts has not been well documented, and in regions where historical records are absent, it is unclear whether or not contemporary surveys are representative of past and present freshwater mussel communities.

This case study compares the late Holocene and modern unionid biogeography of the Upper Trinity River using zooarchaeological data with a focus on the bankclimber (*Plectomerus dombeyanus*). The Trinity River in north Texas comprises the Clear, West, and Elm Forks along with their associated tributaries. The rivers were impounded between 1914 and 1957 for flood control (Dowell and Breeding 1967). Archaeological sites relevant to this study are located near impoundments. These sites date to the late Holocene between 1450 and 600 years before present based on radiocarbon dates of ash deposits (Lintz et al. 2008) and associated artifacts (Ferring and Wolverton, unpublished data).

Little is known about the distribution of freshwater mussels in the Upper Trinity (Neck 1990). The few historical records concern the Elm Fork near Dallas (e.g., Neck 1990; Read 1954; Strecker 1931) and the Clear and West Forks near Fort Worth (Mauldin 1972). Surveys have focused on reservoirs and nearby rivers (Howells 2006), and contemporary biologists describe the Upper Trinity River as being intermittent upstream from Dallas but supporting a diverse community of freshwater mussels (e.g., Neck 1990). This high diversity is thought to relate to diverse habitat and fish stocking in nearby reservoirs (Read 1954). During the early 1950s investigators observed the deleterious effects of industrial effluent on mussel populations near Dallas, causing the extirpation of at least one unionid species (Read 1954).

Unionid biogeography within the Trinity River has been categorized into an “upland” and “lowland” component (Neck 1990). The upland component of the Trinity is delineated by the absence of species thought only to occur in large perennial sandy-bottomed streams, characterizing much of the lower Trinity River north of Houston. The upland habitat of the Trinity River near Dallas and Fort Worth was thought to have been poor for certain lowland species (Strecker 1931). The classification of the Trinity River into these two faunal components stems from a small number of early surveys near Dallas following the impoundment of the Trinity River (Neck 1990). Consequently, these surveys are likely *representative of human impacts related to construction of impoundments on and release of wastewater effluent into the Trinity River*. The unionid species within the upper Trinity during the 1930s should be those that are tolerant to changes in hydrological characteristics associated with impoundments and modern wastewater release (see Vaughn and Taylor 1999; Watters 1999). Given the problems with historical unionid records (see above), the late Holocene zooarchaeological record provides a means to test whether or not lowland species existed in the Upper Trinity prior to impoundment.

Twelve unionid species were identified from four archaeological sites in the Upper Trinity River drainage. The bankclimber (*P. dombeyanus*) is considered a member of the lowland component of the Trinity River (see Table 8.3). Shells of this species have been recovered at archaeological sites on the Clear and West Forks of the Trinity River and on Denton Creek, suggesting a ubiquitous distribution during the late Holocene. This species predominately occurs in perennial sluggish lowland rivers, near stream banks, and in shallow waters with mud sand or gravel substratum (Howells et al. 1996). In Texas, modern records for this species occur mainly in the eastern and southern portions of the state downstream from the Upper Trinity River.

The presence of *P. dombeyanus* at these four zooarchaeological sites represents an extra-limital record for this region. The habitat requirements of this species suggest that the Upper Trinity River and associated tributaries were not intermittent but were in fact shallow, slow

Table 8.3 List of “Lowland” Species and their Presence or Absence in the Upper Trinity River Drainage

Lowland species	Common name	Upper Trinity River
<i>Fusconaia flava</i>	Wabash pigtoe	A
<i>Megaloniaias nervosa</i>	Washboard	A
<i>Plectomerus dombeyanus</i>	Bankclimber	P ^a
<i>Strophitus undulatus</i>	Squawfoot	A
<i>Truncilla donaciformis</i>	Fawnsfoot	A

^aDenotes late Holocene paleozoological presence in the region.

moving, sand bottomed rivers prior to impoundment; other species found at these archaeological sites support this assertion (Randklev et al. 2009). The historical distribution of lowland species in the Trinity River most likely reflects a tolerance gradient to human impacts and a paucity of historical distribution records. The absence of historical records for the bankclimber in the Upper Trinity may reflect poor sampling of species intolerant of the acute changes that have occurred in this region. Modern studies of freshwater mussels describe extirpation gradients downstream of impoundments; that is, species richness tends to increase with linear distance from these impacts (see Vaughn and Taylor 1999). Interestingly, the bankclimber is considered an opportunistic species tolerant of anthropogenic impacts (Miller et al. 1992; Peacock and James 2002). Why are these species and other lowland ones not found in the Upper Trinity River today? Additional zooarchaeological data could provide answers to this question by providing appropriate time frames to assess when lowland component species were reduced in both abundance and distribution in the Upper Trinity River.

The Biogeographic Potential of Archaeological Organic Residues

Over the past 20 years, the popularity of organic residue analysis in archaeology has increased (Eerkens and Barnard 2007). In part, this is due to improvements in analytical chemistry as well as the realization that organic compounds such as DNA, proteins, lipids, alkaloids, and starches can be preserved for lengthy periods in a wide variety of contexts including in bone (Evershed et al. 1995), within ceramic artifacts (Craig et al. 2005), in mummified remains (Pääbo 1985), on lithic tools (Kooyman et al. 2001), and in fossils (Asara et al. 2007).

Archaeological residue studies have focused on addressing questions of artifact function and/or dietary practices (e.g., Craig et al. 2005; Eerkens 2005). They have also addressed other topics such as the origins of domestication (Outram et al. 2009) and the translation of Mayan hieroglyphs (Hall et al. 1990). The success of these studies and others has resulted from collaboration between researchers from diverse disciplines relying on a “weight of evidence” approach (O’Hara 1988). Outram et al. (2009), for example, use skeletal morphology, dental wear patterns, and organic residue analysis in concert to demonstrate the likely domestication of horses in Kazakhstan circa 5500 years before present.

As the development of organic residue analysis continues, we believe that the study of archaeological residues has the potential to shed light on the past when other lines of evidence, such as faunal remains, are unavailable (Lyman 1996: 120). Further, the information gained from such studies can also inform us about the biogeography of prehistoric taxa.

Proteins, in particular, hold promise for biogeographic studies of prehistoric organisms. Although they present methodological challenges, including the difficulty of extraction from ceramic artifacts (Craig and Collins 2002), protein residues possess qualities ideally suited for biogeographic research. As products of DNA, many proteins are taxonomically specific; with some exceptions, their unique amino acid sequences can be attributed to particular genera or even species of organisms (Barnard et al. 2007). Proteins are more abundant than DNA, increasing their likelihood of survival and subsequent extraction (Barnard et al. 2007). Also, the very properties that make them difficult to extract from ceramic matrices ensure that they are not lost from archaeological samples through exposure to water. Surprisingly, protein residues have even been demonstrated to adhere to non-ceramic surfaces for several thousand years despite exposure to moisture (Kooyman et al. 2001). The

popularity of proteomics, particularly in medical and forensic sciences, provides a growing body of research on protein extraction and characterization in addition to ample opportunities for collaboration.

Protein residues recovered from artifacts can provide evidence regarding the past distribution of species. This can be used to guide modern conservation/restoration efforts. Although consideration of temporal and spatial provenience of artifacts is required in order to rule out the confounding effects of long distance transport (Lyman 1996), the identification of taxa via residue analysis could play important roles in several debates.

The Missouri Department of Conservation (MDC) considered reintroducing elk (*Cervus elaphus*) to a region of the Ozark Highlands in the light of historical accounts documenting their presence prior to the mid-1800s. Noting the failure of the MDC to consider alternative lines of evidence, Harpole (2004) inventoried Missouri paleozoological samples with elk remains to ascertain whether elk ever lived within and around the proposed reintroduction area during the Holocene. She concludes that the absence of elk remains within the reintroduction area argues against the MDC's reintroduction plan. Although Harpole's point is well made, she explains that the scarcity of faunal remains in this region highlights a need for skepticism of her results, which may lead to her data being ignored by policy-makers. Analysis of artifact residues could extend her claims. Ceramic remains are common in late prehistoric archaeological assemblages in Missouri (O'Brien and Wood 1998), and if several artifacts from multiple sites in the reintroduction area were to yield quantifiable and identifiable residues (a probable outcome) the results would be relevant. If no residues from elk were to occur, Harpole's (2004) cautionary note on the proposed reintroduction by MDC would be supported. Protein analysis offers a unique opportunity to evaluate the debate over Pleistocene megafaunal extinction. Although we are skeptical regarding claims of overkill, a comprehensive residue analysis of Clovis-era projectile points could provide the "smoking gun" by demonstrating which species were being hunted by Pleistocene peoples. Kooyman et al. (2001) have already demonstrated the feasibility of this strategy, identifying protein residues on stone tools that link Late Pleistocene hunters to previously undocumented prey such as felines (Felidae), bears (*Ursus* spp.) and the extinct North American horse (*Equus conversidens*). Further studies, if successful in identifying a wide range of now extinct species on artifacts, would be a meaningful line of evidence in the extinction debate. Hyland et al. (1990) are among the first to explicitly recognize the relevance of protein residue analysis to biogeography. In their study of archaeological residues from the Shoop site, Pennsylvania, they identified cervid protein residues on a Paleoindian uniface. Unfortunately, they were unable to resolve which particular species of cervid was present. However, they insightfully commented that, "depending on the type of cervid ultimately identified, very different environmental reconstructions may be developed for this part of central Pennsylvania" (Hyland et al. 1990: 110).

There are several methodological and interpretive issues in archaeological residue analysis, and caution is required in the evaluation of results (Brandt et al. 2002). Nevertheless, we believe that its continued development, particularly with regard to the use of protein-based strategies, will provide useful qualitative and quantitative data in a wide range of disciplines.

DISCUSSION

Ethnobiology brings an explicitly evolutionary perspective to environmental science and ethics; this is especially the case with applied paleozoology because of its inherently

temporal perspective. Although Callicott's recommendation that benchmarks for conservation and restoration are most pragmatic at the ecological mesoscale, the effects of modern human impacts are evolutionary in proportion (Russell 2003). Because human impacts (e.g., chemical contamination and habitat fragmentation) change allele frequencies in species' gene pools, they are indisputably evolutionary. An excellent example is the impact of the pollutant tributyl tin (TBT), which is used as an anti-molluscicide on boats and piers, on marine populations of dog whelks (*Nucella lapillus*). Experiments show that TBT causes imposex (the development of male sexual characteristics by females) through increasing testosterone production in this mollusk, which results in the growth of a small penis in females that can block egg production (Walker et al. 2001). The impact of TBT pollution thus is a direct population-level response in this species. Some individuals simply cannot reproduce. Gibbs (1993) discovered that individuals in one population evolved modified genitalia that allowed them to persist in the presence of TBT, which represents a substantial shift in the evolutionary history of this species. Though these impacts appear to be reversible and short term, pollution control of TBT cannot reverse the evolutionary, permanent effects on the dog whelk's gene pool, and humans have changed the trajectory of evolution in this species. That ethnobiologists commonly work with the evolving relationships among humans and ecosystems (including constituents of ecological communities, such as dog whelks) from an evolutionary perspective puts them in a position to disclose the evolutionary impacts of the current environmental crisis in terms of culture and biology.

Although recognizable with some effort, the link between ethnobiology and environmental philosophy and environmental science is not very explicit for several reasons (Lepofsky 2009). First, though environmental science is inherently interdisciplinary, its practitioners are only recently acknowledging a need to extend the communication of their results more clearly through education, policy, and public outreach. Environmental philosophy, particularly in the realm of ethics, can assist development of policy in collaboration with environmental scientists. However, the sparse record of collaboration between these two parties indicates that there is a large communication gap. Ethnobiologists can bridge this gap, because the products of our research, by the nature of the field itself, transcend cultural, temporal, and spatial boundaries.

A second reason has to do with methodology. Environmental sciences, particularly subdisciplines such as ecotoxicology and environmental chemistry, are experimental. Experimental results are highly controlled and replicable, but such is not the nature of methodology in ethnobiology. Ethnobiologists rely on the weight of evidence to draw conclusions (*sensu* Ereshefsky 1992; O'Hara 1988); hypotheses are rejected as explanations for patterns and trends when there is no, or very little, evidence to support them. Swetnam et al. (1999) provide excellent examples from the realm of historical ecology in which they use multiple lines of evidence, including repeated photography, dendrochronology, aerial photography, and historical records to infer whether or not changes in plant communities are the product of natural changes (e.g., the products of fire histories) or modern human impacts (e.g., overgrazing by livestock).

A third reason is the distraction of "anthropogenism." Much attention has been devoted to dismantling the myth of the "ecologically noble savage" (Alvard 1998; Peacock 1998; see references in Penn and Mysterud 2007b), but this myth has been replaced with an equally damaging dogma implying that because humans do not conserve resources in ecologically noble ways all humans cause major environmental damage. Rozzi (1999) attempts to erode the epistemological difference between humans and nature; he views such erosion as essential if humanity is to value nature in ways that solve environmental problems. At what point

in human evolution did human actions prevent *more* ecosystem services than they provided? Whether or not hunter-gatherers *intentionally* practiced conservation, though important anthropologically, may not be of great concern to environmental scientists because the spatial and temporal scales (local and regional) of their impacts were low compared to those of industrial and post-industrial societies (continental and global). Hunn (1982) terms the lower environmental impact of such small-scale societies “epiphenomenal conservation,” which operates through a process of what Wyndham (2009) refers to as “subtle ecologies.” Subtle ecologies are human–environment interactions comprising “slow relations that rely on diffuse causalities and micro-effects related to invisible or fleeting action” (Wyndham 2009: 272). A monolithic anthropogenism ignores these subtle ecologies.

CONCLUSION

Paleozoological, paleoethnobotanical, and/or historical ecological datasets must be consulted in diverse ways. Indeed, taphonomic histories of archaeological and paleontological assemblages vary by context (Lyman 1994; Nagaoka et al. 2008). The task of the paleoethnobiologist is then to recognize the diverse nature of these records (which most practitioners do) and their unique potential applications in conservation and restoration (see Lepofsky 2009; Lyman 2006; Stahl 1996; Swetnam 1999; Wolverson et al. 2007). The most important value of these applied-paleo approaches, however, may not be the precise outcomes of case studies; instead, it is the shift in temporal scale that they provide. “Sustainability” is defined in environmental science as “solutions to environmental problems that benefit *future* generations.” We find the perspective of applied paleozoology priceless in terms of promoting long-term solutions. This advantage, however, needs ethnobiology and its constituent disciplines as a bridge lending multiple disclosive perspectives to modern environmental science through transcendence of spatial, temporal, and cultural paradigms.

ACKNOWLEDGMENTS

The authors thank Barney Venables, James Kennedy, Lisa Nagaoka, John Cornelius, Kevin Cagle, and especially Lee Lyman and Nancy Turner.

REFERENCES

- ALVARD MS. Evolutionary ecology and resource conservation. *Evol Anthropol* 1998;7(2):62–74.
- ASARA JM, SCHWEITZER MH, FREINMARK LM, PHILLIPS M, CANTLEY LC. Protein sequences from mastodon and *Tyrannosaurus rex* revealed by mass spectrometry. *Science* 2007;316(5822):280–285.
- BARNARD H, SHOEMAKER L, CRAIG OE, RIDER M, PARR RE, SUTTON MQ, YOHE RM II. Introduction to the analysis of protein residues in archaeological ceramics. In: BARNARD H, EERKENS JW, editors. *Theory and practice of archaeological residue analysis*. BAR International Series Volume 1650. Oxford: Archaeopress; 2007. p 216–228.
- BECKMANN JP, BERGER J. Rapid ecological and behavioral changes in carnivores: the responses of black bears (*Ursus americanus*) to altered food. *J Zool* 2003;261(2): 207–212.
- BOGAN AE. Freshwater bivalve extinctions (Mollusca: Unionoidea): a search for causes. *Amer Zool* 1993;33(5): 599–609.
- BORGERHOFF MULDER M, COPPOLILLO P. *Conservation: linking ecology, economics, and culture*. Princeton (NJ): Princeton University Press; 2005.
- BORGMANN A. The transparency and contingency of the earth. In: FRODEMAN R, editor. *Earth matters: the earth sciences, philosophy, and the claims of community*. Upper Saddle River (NJ): Prentice Hall; 2000. p 99–106.
- BRANDT E, WIECHMANN I, GRUPE G. How reliable are immunological tools for the detection of ancient proteins in fossil bones? *Int J Oseoarchaeol* 2002;12(5): 307–316.
- BROWN MF. Cultural relativism 2.0. *Curr Anthropol* 2008;49(3):363–383.

- BUNNELL FL, TAIT DEN. Population dynamics of bears—implications. In: FOWLER CW, SMITH TD, editors. Dynamics of large mammal populations. New York: John Wiley and Sons; 1981; p 75–98.
- BUTLER VL, DELACORTE MG. Doing zooarchaeology as if it mattered: use of faunal data to address current issues in fish conservation biology in Owens Valley, California. In: LYMAN RL, CANNON KP, editors. Zooarchaeology and conservation biology. Salt Lake City: University of Utah Press; 2004. p 25–44.
- CALLICOTT JB. Choosing appropriate temporal and spatial scales for ecological restoration. *J Biosci* 2002;27(suppl. 2):409–420.
- CÔTÉ S, ROONEY TP, TREMBLAY C, DUSSAULT C, WALLER DM. Ecological impacts of deer overabundance. *Annu Rev Ecol Evol Syst* 2004;35:113–147.
- CRAIG OE, COLLINS MJ. The removal of protein residues from mineral surfaces: implications for residue analysis of archaeological materials. *J Archaeol Sci* 2002;29(10):1077–1082.
- CRAIG OE, CHAPMAN J, HERON CP, WILLIS LH, TAYLOR G, WHITTLE A, COLLINS MJ. Did the first farmers of central and eastern Europe produce dairy foods? *Antiquity* 2005; 79(306):882–894.
- DONLAN J, GREENE HW, BERGER J, BOCK CE, BOCK JH, BURNEY DA, ESTES JA, FOREMAN D, MARTIN PS, ROEMER GW, SMITH FA, SOULÉ ME. Re-wilding North America. *Nature* 2005;436(7053):913–914.
- DOWELL CL, BREEDING SD. Dams and reservoirs in Texas: historical and descriptive information. Report nr 148. Austin: Texas Water Development Board; 1967.
- DUNNELL RC. Science, social science, and common sense: the agonizing dilemma of modern archaeology. *J Anthropol Res* 1982;38(1):1–25.
- EERKENS J. GC-MS analysis and fatty acid ratios of archaeological potsherds from the western Great Basin of North America. *Archaeometry* 2005;47(1):83–102.
- EERKENS JW, BARNARD H. Introduction. In: BARNARD H, EERKENS JW, editors. Theory and practice of archaeological residue analysis. BAR International Series Volume 1650. Oxford: Archaeopress; 2007. p 1–7.
- EMSLIE SD. Age and diet of fossil California condors in Grand Canyon, Arizona. *Science* 1987;237(4816): 768–770.
- ERESHEFSKY M. The historical nature of evolutionary theory. In: NITECKI MH, NITECKI DV, editors. History and evolution. Albany: State University of New York Press; 1992. p 81–99.
- EVERSHED RP, TURNER-WALKER G, HEDGES REM, TUROSS N, LEYDEN A. Preliminary results for the analysis of lipids in ancient bone. *J Archaeol Sci* 1995;22(2): 277–290.
- FERRING CR. Middle Holocene environments, geology, and archaeology in the southern Plains. In: BETTIS EA III, editor. Archaeological geology of the Archaic period in North America. Special Paper 297. Boulder (CO): Geological Society of America; 1995.
- FRAZIER J. Sustainable use of wildlife: the view from archaeozoology. *J Nat Conserv* 2007;15(3):163–173.
- GALBRAITH HS, SPOONER DE, VAUGHN CC. Status of rare and endangered freshwater mussels in southeastern Oklahoma rivers. *Southwest Nat* 2008;53(1):45–50.
- GARSHELIS DL, HELLGREN EC. Movements of black bears in the Great Smoky Mountains National Park. *J Wildl Manage* 1981;45(4):912–925.
- GEIST V. Deer of the world: their evolution, behavior, and ecology. Mechanicsburg (PA): Stackpole Books; 1998.
- GIBBS PE. A male genital defect in the dog whelk, *Nucella lapillus* (Neogastropoda), favouring survival in a TBT-polluted area. *J Mar Biol Assoc UK* 1993; 73(3):667–678.
- GRAHAM RW. The role of climate change in the design of biological preserves. *Conserv Biol* 1988;2(4):391–394.
- GRAYSON DK. Quantitative zooarchaeology. Orlando (FL): Academic Press; 1984.
- GRAYSON DK. The Late Quaternary biogeographic histories of some Great Basin mammals (western USA). *Quatern Sci Rev* 2006;25(21–22):2964–2991.
- GRAYSON DK, MELTZER DJ. A requiem for North American overkill. *J Archaeol Sci* 2003;30(5):585–593.
- HALL GD, TARKA SM JR, HURST WJ, STUART D, ADAMS REW. Cacao residues in ancient Maya vessels from Rio Azul, Guatemala. *Am Antiq* 1990;55(1):138–143.
- HARPOLE JL. Zooarchaeological implications for Missouri's elk (*Cervus elaphus*) reintroduction effort. In: LYMAN RL, CANNON KP, editors. Zooarchaeology and conservation biology. Salt Lake City: University of Utah Press; 2004. p 103–115.
- HILDEBRAND DK. Statistical thinking for behavioral scientists. Boston (MA): Prindle, Weber, and Schmidt Publishers; 1986.
- HILL ME, HILL MG, WIDGA CC. Late Quaternary bison diminution on the Great Plains of North America: evaluating the role of human hunting versus climate change. *Quatern Sci Rev* 2008;27(17–18):1752–1771.
- HOWELLS RG. Statewide freshwater mussel survey: final report. Austin: Texas Parks and Wildlife Department; 2006.
- HOWELLS RG, NECK RW, MURRAY HD. Freshwater mussels of Texas. Austin: Texas Parks and Wildlife Press; 1996.
- HUNN ES. Mobility as a factor limiting resource use in the Columbia Plateau of North America. In: WILLIAMS SM, HUNN ES, editors. Resource managers: North American and Australian hunter-gatherers. Selected Symposium 67. American Association for the Advancement of Science; 1982. p 17–43.
- HUNTER M JR. Benchmarks for managing ecosystems: are human activities natural? *Conserv Biol* 1996;10(3): 695–697.
- HYLAND DC, TERSAK JM, ADOVASIO JM, SIEGEL MI. Identification of the species of origin of residual blood on lithic material. *Am Antiq* 1990;55(1):104–112.
- KIE JG, WHITE M, DRAWE DL. Condition parameters of white-tailed deer in Texas. *J Wildl Manage* 1983; 47(3):583–594.
- KOORYMAN B, NEWMAN ME, CLUNEY C, LOBB M, TOLMAN S, MCNEIL P, HARRIS LV. Identification of horse exploitation

- by Clovis hunters based on protein analysis. *Am Antiq* 2001;66(4):686–691.
- LANDRES PB. Temporal scale perspectives in managing biological diversity. *Trans North Amer Wildl Nat Res Conf* 1992;292–307.
- LEPOFSKY D. The past, present, and future of traditional resource and environmental management. *J Ethnobiol* 2009;29(2):161–166.
- LINTZ C, HALL SA, BAUGH TG, OSBURN T. Archeological testing at 41TR170, along the Clear Fork of the Trinity River, Tarrant County, Texas. *Miscellaneous reports of investigations nr 348. Geo-Marine*; 2008.
- LYDEARD C, COWIE RH, PONDER WF, BOGAN AE, BOUCHET P, CLARK SA, CUMMINGS KS, FREST TJ, GARGOMINY O, HERBERT D, HERSHLER R, PEREZ KE, ROTH B, SEDDON M, STRONG EE, THOMPSON FG. The global decline of nonmarine mollusks. *Bioscience* 2004;54(4):321–330.
- LYMAN RL. Zoogeography of Oregon coast mammals: the last 3000 years. *Mar Mam Sci* 1988;4(3):247–264.
- LYMAN RL. Vertebrate taphonomy. New York: Cambridge University Press; 1994.
- LYMAN RL. Applied zooarchaeology: the relevance of faunal analysis to wildlife management. *World Archaeol* 1996;28(1):110–125.
- LYMAN RL. White goats white lies: the abuse of science in Olympic National Park. Salt Lake City: University of Utah Press; 1998.
- LYMAN RL. Paleozoology in the service of conservation biology. *Evol Anthropol* 2006;15(1):11–19.
- LYMAN RL. Quantitative paleozoology. New York: Cambridge University Press; 2008.
- LYMAN RL, CANNON KP, editors. Zooarchaeology and conservation biology. Salt Lake City: University of Utah Press; 2004.
- MARTIN PS. The discovery of America. *Science* 1973;179(4077):969–974.
- MAULDIN VL. The bivalve mollusca of selected Tarrant County, Texas reservoirs [Master's Thesis]. Fort Worth: Texas Christian University; 1972.
- MILLER GT. Living in the environment: principles, connections, and solutions. Belmont (CA): Thomson Learning; 2007.
- MILLER AC, PAYNE BS, HARTFIELD PD. Characterization of a freshwater mussel (Unionidae) community in the Big Sunflower River, Sharkey County, Mississippi. *J Miss Acad Sci* 1992;37(3):8–11.
- NABHAN GP. Ethnoecology: bridging disciplines, cultures and species. *J Ethnobiol* 2009;29(1):3–7.
- NAGAOKA L, WOLVERTON S, FULLERTON B. Taphonomic analysis of the Twilight Beach seals. In: CLARK G, LEACH F, O'CONNOR S, editors. Islands of inquiry: colonisation, sea-faring, and the archaeology of maritime landscapes. *Terra Australis* 29. Canberra: Australian National University Press; 2008. p 475–498.
- NECK RW. Geological substrate and human impact as influences on bivalves of Lake Lewisville, Trinity River, Texas. *Nautilus* 1990;104(1):16–25.
- O'BRIEN MJ, WOOD WR. The prehistory of Missouri. Columbia: University of Missouri Press; 1998.
- OELSCHLAEGER M. Natural aliens reconsidered: causes, consequences, and cures. In: FRODEMAN R, editor. Earth matters: the earth sciences, philosophy, and the claims of community. Upper Saddle River (NJ): Prentice Hall; 2000. p 107–118.
- O'HARA RJ. Homage to Clio, or, toward an historical philosophy for evolutionary biology. *Syst Zool* 1988;37(2):142–155.
- OUTRAM AK, STEAR NA, BENDREY R, OLSEN S, KASPAROV A, ZAIBERT V, THORPE N, EVERSLED RP. The earliest horse harnessing and milking. *Science* 2009;323(5919):1332–1335.
- PAÄBO S. Preservation of DNA in ancient Egyptian mummies. *J Archaeol Sci* 1985;12(6):411–17.
- PEACOCK E. Historical and applied perspectives on prehistoric land use in eastern North America. *Environ Hist* 1998;4(1):1–29.
- PEACOCK E, JAMES TR. A prehistoric unionid assemblage from the Big Black River drainage in Hinds County, Mississippi. *J Miss Acad Sci* 2002;47(2):121–125.
- PENN DJ. Introduction: the evolutionary roots of our ecological crisis. In: PENN DJ, MYSTERUD I, editors. Evolutionary perspectives on environmental problems. New Brunswick (NJ): Aldine Transaction; 2007b; pp. 1–8.
- PENN DJ, MYSTERUD I, editors. Evolutionary perspectives on environmental problems. New Brunswick (NJ): Aldine Transaction; 2007a.
- PURDUE JR. Estimation of body weight of white-tailed deer (*Odocoileus virginianus*) from central Illinois. *J Ethnobiol* 1987;7(1):1–12.
- RANDKLEV CR, WOLVERTON S, KENNEDY JH. A biometric technique for assessing prehistoric freshwater mussel population dynamics (Family: Unionidae) in north Texas. *J Archaeol Sci* 2009;36(2):205–213
- READ LB. The Pelecypoda of Dallas County, Texas. *Field Lab* 1954;22(1):35–51.
- RICK TC, ERLANDSON JM, editors. Human impacts on ancient marine ecosystems: a global perspective. Berkeley: University of California Press; 2008.
- ROLSTON HI. Environmental ethics: duties to and values in the natural world. Philadelphia (PA): Temple University Press; 1988.
- ROZZI R. The reciprocal links between evolutionary–ecological sciences and environmental ethics. *Bioscience* 1999;49(11):911–921.
- RUBENSTEIN DR, RUBENSTEIN DI, SHERMAN PW, GAVIN TA. Pleistocene Park: Does re-wilding North America represent sound conservation for the 21st century? *Biol Conserv* 2006;132(2):232–238.
- RUSSELL E. Evolutionary history: prospectus for a new field. *Environ Hist* 2003;8(2):204–228.
- RUSSELL FL, FOWLER NL. Rarity of oak saplings in savannas and woodlands of the eastern Edwards Plateau, Texas. *Southwest Nat* 1999;44(1):31–41.
- RUSSELL FL, FOWLER NL. Effects of white-tailed deer on the population dynamics of acorn seedlings and small saplings of *Quercus buckleyi*. *Plant Ecol* 2004;173(1):59–72.

- SCHWARTZ CW, SCHWARTZ ER. The wild mammals of Missouri. Columbia, MO: University of Missouri Press and Missouri Department of Conservation; 2001.
- SIMARD MA, CÔTÉ S, WELADJI RB, HUOT J. Feedback effects of chronic browsing on life-history traits of a large herbivore. *J Anim Ecol* 2008;77(4):678–686.
- SIMPSON GG. Historical science. In: ALBRITTON JCC, editor. The fabric of geology. Stanford (CA): Freeman, Cooper, and Company; 1963. p 24–48.
- SMITH KG, CLARK JD. Black bears in Arkansas: characteristics of a successful translocation. *J Mammal* 1994; 75(2):309–320.
- STAHL PW. Holocene biodiversity: an archaeological perspective from the Americas. *Annu Rev Anthropol* 1996; 25:105–126.
- STRECKER JK. The distribution of the naiades or pearly freshwater mussels of Texas. Special Bulletin 2. Waco (TX): Baylor University Museum; 1931.
- SWETNAM TW, ALLEN CD, BETANCOURT JL. Applied historical ecology: using the past to manage for the future. *Ecol Appl* 1999;9(4):1189–1206.
- TEER JG. Lessons from the Llano Basin, Texas. In: HALLS LK, editor. White-tailed deer ecology and management. Harrisburg (PA): Stackpole Books; 1984. p 261–290.
- VALENTINE K, DUFFIELD DA, PATRICK LE, HATCH DR, BUTLER VL, HALL RL, LEHMAN N. Ancient DNA reveals genotypic relationships among Oregon populations of the sea otter (*Enhydra lutris*). *Conserv Genet* 2008; 9(4):933–938.
- VAN WILLIGEN J. Applied anthropology: an introduction. Westport (VA): Bergen and Garvey; 2002.
- VAUGHN CC, TAYLOR CM. Impoundments and the decline of freshwater mussels: a case study of an extinction gradient. *Conserv Biol* 1999;13(4):912–920.
- WALKER CH, HOPKIN SP, SIBLY RM, PEAKALL DB. Principles of ecotoxicology. 2nd ed. New York: Taylor and Francis; 2001.
- WALTON MT. Nuisance wildlife and land use. In: TELFAIR RC II, editor. Texas: wildlife resources and land uses. Austin: University of Texas Press; 1999. p 259–273.
- WATTERS TG. Freshwater mussels and water quality: a review of the effects of hydrologic and instream habitat alterations. In: TANKERSLEY RA, WARMOLTS DI, WATTERS GT, ARMITAGE BJ, JOHNSON PD, BUTLER RS, editors. Proceedings of the First Freshwater Mollusk Conservation Society Symposium. Columbus: Ohio Biological Survey; 1999. p 261–274.
- WELLS PH. Bear bones from a Boone County cave. *Natl Speleolog Soc Bull* 1959;21(1):13–14.
- WOLVERTON S. Caves, ursids, and artifacts: a natural-trap hypothesis. *J Ethnobiol* 2001;21(2):55–72.
- WOLVERTON S. Natural-trap ursid mortality and the Kurtén Response. *J Hum Evol* 2006;50(5):540–551.
- WOLVERTON S. Harvest pressure and environmental carrying capacity: an ordinal scale model of effects on ungulate prey. *Am Antiq* 2008a;73(2):179–199.
- WOLVERTON S. Characteristics of late Holocene American black bears in Missouri: evidence from two natural traps. *Ursus* 2008b;19(2):177–184.
- WOLVERTON S, KENNEDY JH, CORNELIUS JD. A paleozoological perspective on white-tailed deer (*Odocoileus virginianus texana*) population density and body size in central Texas. *Environ Manage* 2007;39(4): 545–552.
- WOLVERTON S, LYMAN RL, KENNEDY JH, LA POINT TW. The terminal Pleistocene extinction in North America, hypermorphic evolution, and the dynamic equilibrium model. *J Ethnobiol* 2009a;29(1):28–63.
- WOLVERTON S, HUSTON MA, KENNEDY JH, CAGLE K, CORNELIUS JD. Conformation to Bergmann's rule in white-tailed deer can be explained by food availability. *Am Midl Nat* 2009b;162(2):403–417.
- WYNDHAM FS. Spheres of relations, lines of interaction: subtle ecologies of the Rarámuri landscape in northern Mexico. *J Ethnobiol* 2009;29(2):271–295.

Chapter 9

Ethnobotany: The Study of People–Plant Relationships

JUSTIN M. NOLAN

Department of Anthropology, University of Arkansas, Fayetteville, AR

NANCY J. TURNER

School of Environmental Studies, University of Victoria, Victoria, BC, Canada

INTRODUCTION	133
THE DEVELOPMENT OF ETHNOBOTANY	134
METHODS IN ETHNOBOTANY	139
CLASSIC CASE STUDIES AND THEIR CONTRIBUTIONS TO ETHNOBOTANICAL PRAXIS	141
INTERGENERATIONAL RESEARCH IN MEDICAL ETHNOBOTANY	141
USING PALEOETHNOBOTANY TO UNDERSTAND THE PAST: ÖTZI AND KWÄDAY DÄN TS'INCHÍ	141
SOLVING THE MYSTERY OF A NOTORIOUS ILLNESS: ETHNOBOTANY AND CYCAD TOXICITY	143
CONCLUSION	143
REFERENCES	145

INTRODUCTION

Ethnobotany's development has challenged the prevailing trend in academic studies of the twentieth century of disciplinary specialization. It reflects congruence with our human efforts to understand our place in the world. It parallels other interdisciplinary fields: environmental history, political ecology, cultural ecology, environmental ethics, ecological economics, and ecological restoration.

Linked to ethnobotany are taxonomy, nutrition, pharmacognosy, phytochemistry, palynology, ecology, and conservation biology. Ethnobotany has also been constructed to include studies of those life forms traditionally, but no longer, considered as plants: algae,

lichens, and fungi. On the social sciences and humanities side are anthropology, political science, geography, environmental studies, economics, psychology, linguistics, and philosophy, among others.

Ethnobotany can lead to a fascinating and fulfilling career, whether in a university, a community, government, international agencies, or non-government organizations. There is room for people who enjoy analytical and statistical methods, for those who prefer qualitative methods, and for those who like to use multiple-method approaches. Although some ethnobotanical studies can be conducted in a botanical, archaeological, linguistics or computer laboratory or in a herbarium (where plant specimens are identified and stored as records), most ethnobotanists find that working collaboratively with other people at a personal and community level is a major and essential part of research in ethnobotany. Most ethnobotanical research requires fieldwork in the outdoors for at least part of any project. Participatory research is common.

Methods that ethnobotanists employ include: note taking, photography, tape and video recording, statistics, collecting and preparing plant specimens, microscope work, analysis of nutrients and plant chemicals, genetic studies, and ecological survey work. Presentation of results is by writing for publication, giving public presentations, conducting workshops, teaching, and outreach. Collaborative work between academic ethnobotanists and Indigenous or other local plant and cultural specialists can benefit both communities and researchers. Ethnobotanical studies need not be confined to far-away places or different cultures; people everywhere have knowledge of plants.

Ethnobotany has achieved a relatively high profile in recent years. A quick web check of “ethnobotany” in October 2008 revealed that there were 669,000 Google hits for this term, 33,000 more than in a similar search in March 2005. The exotic nature of some ethnobotanical studies, notably the work of ethnobotanists such as Richard Evans Schultes (Schultes and Hofmann 1987) and his students such as Wade Davis (1997) and Mark Plotkin (1993) with remote peoples and plants of the South American Amazon, has captured the imagination of many, and has even resulted in Hollywood images of ethnobotanists in romanticized situations, interacting with new tribal peoples in far-away jungles and “discovering” new medicines for treating cancer or other difficult diseases. While there is an undeniable lure of adventure in ethnobotanical research, it is the recognition of the critical importance of the diversity of environments and human knowledge systems based on them that drives these and other ethnobotanists in their work. Most ethnobotanists love plants and diverse ecosystems, and have a deep interest in human adaptations and innovations, which allow some people to live in places where many others would not be able to survive. Most ethnobotanists believe that the collective environmental knowledge of humanity is essential in efforts to conserve the earth’s biodiversity. Certainly, one of the striking correlations that Wade Davis (2001) and other ethnobotanists have helped to identify is the close correspondence between the earth’s biological diversity and its cultural diversity (Carlson and Maffi 2004). Regions of high biological diversity in the world correlate strongly with the regions of highest linguistic and cultural diversity (Stepp et al. 2005).

THE DEVELOPMENT OF ETHNOBOTANY

In 1893, a unique collection of botanical objects exhibited at the Chicago World’s Fair caught the attention and imagination of John W. Harshberger, an archaeologist with a keen interest in plants. This collection inspired Harshberger to propose a new field of study, written up in the *Botanical Gazette* in an article entitled “The purposes of

ethno-botany” (1896). He emphasized the significance of the World’s Fair collection: “Never before in the history of American archaeology had such a completed series been brought together for study and comparison . . . plant products in the form of food, dress, and household utensils being very largely represented. . . .” He suggested that the topic it represented should become a designated area of study, “ethno-botany,” which would aid in “. . . elucidating the cultural position of the tribes who used the plants for food, shelter or clothing.” As a male academic of the late nineteenth century, his writings and ideas represented the state of society and anthropological thought of his day. In discussing how comparisons could be made in plant use across human cultures, he submitted, “The well-known classification of men into savage, pastoral, agricultural and civilized will roughly serve our purpose. . . .” He described the Indigenous peoples of the southwestern United States simplistically as follows: “. . . a roving people, traveling from place to place in search of game and settling only long enough to plant a little corn, beans and pumpkins to break the monotony of a too strict animal diet. Where they did not pursue agriculture, they subsisted on the seeds of wild grasses and herbs. The cliff dwelling peoples, probably driven to the mountain fastnesses, had practically left the hunter stage and had begun to enter the agricultural stage” (Harshberger 1896: 146).

Harshberger’s conception of ethnobotany—recording the uses of plants by “primitive” peoples—was undeniably limited in scope, but it was a beginning. Some of his suggestions, such as creating ethnobotanical gardens that would feature culturally important plants, stimulating interest in their names and applications by various peoples, and providing specimens and opportunities for scientific study, are as relevant today as they were over a century ago. Others became captivated, and many researchers began documenting ethnobotanical knowledge of the peoples and languages they were studying.

Meanwhile, anthropology as a field was maturing and, with it, ethnobotany was also expanding its horizons. In 1994, Richard Ford published an elegant “tree-ring” schematic to represent the evolution of ethnobotany as a discipline since its inception (Ford 1994).

Harshberger’s cultural evolution assumptions are no longer accepted. The shift in underlying premises has led to a more inclusive, effective, and realistic approach in ethnobotany. The beginnings of this respectful relationship are seen in the work of Richard Evans Schultes (1915–2001), whose compelling photographs and participatory research with Amazonian healers inspired a whole generation of ethnobotanists, and raised the profile, status, and legitimacy of traditional healers and other specialists both within their communities and beyond (Anderson 2001).

Ties with cognitive anthropology opened the field of ethnobotanical and ethnobiological classification, pioneered by Harold Conklin with his doctoral dissertation, *The Relation of Hanunóo Culture to the Plant World* (1954), which reflected meticulous research and observations of one agricultural group in the Philippines. Conklin discovered a surprisingly extensive lexicon of plants, consisting of over 1800 terms, categorized by an elegant, hierarchical principle of organization. Brent Berlin and his colleagues (Berlin 1972, 1992; Berlin et al. 1966) followed with numerous proposals of universal principles of classification and nomenclature applicable across human languages. During the 1970s and 1980s, researchers constructed and contested theories of human cognition *vis-à-vis* ethnological evaluations of culturally salient plants and their corresponding names and uses (Brown 1984; Dougherty 1978; Hunn and Brown, 2011). The cognitive dimension of ethnobotany is relevant to understanding interrelations between language, thought, and memory in human societies (Nolan 2002, 2007; Shipman and Boster 2008).

Studies of the role of plants in folklore, narrative, ceremony and worldview have emerged within ethnobotany, and the variation in knowledge and perspectives of plants

across societal subgroups based on age, gender, social status, and specialization has also gained interest (Table 9.1). As the environmental movement became prominent in the late 1960s and early 1970s, ethnobotanists examined the role of a people's knowledge of plants and environments in the areas of conservation, and how a culture's underlying philosophy and worldview can influence its collective behavior towards other species and the environment in general. This area of focus was certainly strengthened by the publication of the Brundtland Commission report, *Our Common Future* (United Nations Commission on Environment and Development 1987), which emphasized the need to recognize Indigenous and local peoples' knowledge systems in our global search for sustainability and biodiversity conservation. Since this time, Traditional Ecological Knowledge (TEK), including diverse traditional land and resource management methods, has been a prominent and important aspect of ethnobotanical studies (Anderson 2005b; Deur and Turner 2005; Minnis and Elisens 2000; Nazarea 1999). Ethnobotany has become more and more international in its development. Ethnobotanical researchers are prominent in many countries of the world, especially in India, where there are said to be more ethnobotanists *per capita* than in any other country (see Jain 2002).

The international status of ethnobotany in the twenty-first century was prominently reflected in August 2005 at the Fourth International Congress of Ethnobotany, held in Istanbul, Turkey. Hosted by Yeditepe University, with ethnobotanist Z. Füsün Ertug as Congress Secretary, the Congress theme, "Ethnobotany: At the Junction of the Continents and the Disciplines," highlighted the strategic location of ethnobotany at the intersections of disciplines, knowledge systems, cultures, and regions. Ethnobotanists attended this congress from dozens of different countries, from Nepal to Argentina, from Mexico to Iran (Ertug 2006).

Table 9.1 Examples of Some Contemporary Ethnobotanical Research

Topic within ethnobotany	Notes on topic	Some example references
Paleoethnobotany	Ethnobotany of past cultures, including traditional management systems for plant resources	Ford 1978, 1985; Fritz 2005; Lepofsky et al. 2003; Minnis 1991; Minnis and Elisens 2000; Peacock 1998; Pearsall 2001
Historical ecology	Understanding people–plant relationships through time and space	Balée 1998; Ellen 2006; Minnis and Elisens 2000
Nutritional ethnobotany and foodways	Identification and description of nutritional components of native plants in human diet and medicine	Anderson 2005a; Etkin 2006; Johns 1996; Pieroni and Price 2006
Medical ethnobotany	Assessing bioactivity of medicinal plant compounds; designating the cross-cultural applications and significance of botanical families	Etkin 1990; Moerman 1991, 1996; Quinlan 2004; Quinlan et al. 2002; Stepp 2004
Ethnobotanical classification systems	Discovering universal systems of naming and categorizing living things; calibrating folk and scientific thought	Berlin 1992; Brown 1984; Hunn 1982, 1990

(Continued)

Table 9.1 (Continued)

Topic within ethnobotany	Notes on topic	Some example references
Cognitive ethnobotany	Studying distribution and forms of plant knowledge, learning styles, knowledge transmission	Ingold 2004; Nolan 2002, 2007; Sanga and Ortalli 2004; Zarger and Stepp 2004
Symbolic ethnobotany	Examines plants through ritual in folkloristics and ceremonial healing	Quave and Pieroni 2007; Vildarich 2007
Sensory and perceptual ecology	Focuses on human sensory recognition of plants and perceptual distinctiveness	Alcorn 1994, 1995; Boster 1985; Casagrande 2004; Jernigan 2006
Quantitative and experimental ethnobotany	Measuring biodiversity within geographic regions, applying multivariate statistics to assess the use potential of botanical families, genera, and species	Anderson 1993a,b; Martin 1995; Prance et al. 1987; Stepp et al. 2005; Ticktin et al. 2002
Intellectual property rights	Negotiation of legal rights pertaining to Indigenous botanical wisdom, building equitable partnerships	Brush 1996; Moran et al. 2001
Evolutionary ecology	Demonstrates how ethnobotanical knowledge relates to human cognitive development, adaptation, and survival through time and space	Atran et al. 2004; Ellen 2006; Mithen 2006
Interpretive ethnobotany and traditional ecological knowledge	Emphasizes traditional wisdom and philosophies, highlights Indigenous teachings and narratives regarding native plant sustainability	Turner 2006, 2008
Ethnobotany and agrodiversity	Investigating germplasm conservation; implementing “seed banking” of local cultivars to propagate variation and choice in regional cultures	Balick 1996; Brush 2004; Campbell 2005; Nazarea 1999; Veteto and Skarbø 2009
Traditional agricultural systems	Interprets traditional cultivation strategies for selected cultivars, shifting subsistence practices, adaptations to seasonal stress	Estabrook 1998; Nabhan 1989
Ethnobotany and conservation	Identifying and safeguarding biota in accordance with Indigenous priorities	Cunningham 2001; Minnis 2000; Rea 1997
Political ecology	Examines local access to plant resources, institutional policies, dimensions of management and control, grassroots activism	Anderson 2000; Nabhan 2002
Historic migrations and ethnobotany	Analyzes how human movements relate to ethnobotanical cultural memory of economic botany	Pieroni and Vanderbroek 2007; Ramirez-Sosa 2009

Note: The references are examples only; most of these areas are represented by dozens of associated research projects and publications, many of them published in the *Journal of Ethnobiology*.

One of the most important current tasks is the development of ethical protocols for the study of traditional ecological knowledge, or TEK (see Bannister and Hardison, 2011; Gilmore and Eshbaugh, 2011). Traditional ecological knowledge is associated, among other things, with biodiversity research, “bioprospecting,” and cultural conservation (Alexiades and Laird 2002; Maffi 2005; Nolan and Robbins 1999; Zent 1999). Since 1990, globalization and commercialization have dramatically changed the legal environment for ethnobotanical research. No longer associated with mere list making, ethnobotanists are strategically positioned to integrate the priorities of community members with ecological conservation initiatives (Carlson and Maffi 2004). Ethnobotanists who work on the ground, alongside Indigenous people, are keen to recognize the value of local knowledge in addition to their social, ecologic, and economic priorities (Maffi 2005). Many ethnobotanists have begun to design partnerships to ensure that benefits will be shared in ways that are equitable and responsible (Alexiades and Laird 2002; Tobin 2002).

Ethnobotany is closely linked to ethnoecology (see Davidson and Johnson, 2011). Ethnoecology entails interpreting complex resource management strategies. The intrinsic value of diverse ways of knowing, and perpetuating local knowledge, are foci of ethnoecology. This field also emphasizes how and why human feelings, attitudes, values, memories, and emotions become associated culturally with plant-based foods, medicines, and other natural resources (Anderson 1996; Davidson and Johnson, 2011). Knowledge of regional ecosystems, when examined through expressive traditions and customs of use, can revivify resource philosophies and practices (Anderson 2005b; Salmón 2000; Timbrook 2007). Safeguarding biodiversity is a fundamental goal in ethnoecological studies, through “memory banking,” which Nazarea describes as “the parallel collection and documentation of Indigenous knowledge and technologies, including uses, preferences, and evaluation criteria associated with traditional varieties of crops” (Nazarea 1998: 5). Memory banking, when pursued alongside the collection of a germplasm of staple food crops, helps ensure agronomic integrity and the genetic diversity needed to sustain human populations. To offset the impact of agricultural commercialization, ethnoecology seeks to identify and conserve local “heirloom” varieties of subsistence crops, such as the “five finger” sweet potato in the Philippines or the “moon and stars” watermelon in rural Missouri. Local cultivars are themselves representative of cultural diversity the world over (Campbell 2005; Nabhan 1989, 2002).

Another contemporary trend in ethnobotany involves the dynamics between human populations and plant foods and medicines that have historic significance in maintaining human nutrition and health. A growing compendium of edible medicines is being discovered and catalogued by ethnobotanists: chili peppers, seaweed, blackberries, and mushrooms, for example, are valued not only for their role in maintaining cultural identity as edible foods, but also for their powerful healing virtues as flavorful medicines (Etkin et al. 2011; Johns 1996; Pieroni and Price 2006). Recent discoveries of edible medicines, sometimes called nutraceuticals, and the health implications of traditional foodways serve to illustrate the breadth of ethnobotany in a world comprised of increasingly transnational communities (Etkin 2006; Pieroni and Vandebroek 2007). Work in environmental anthropology and ethnopharmacology is presently informed by the fluidity of human movement through time and space. Displaced populations are known to develop social networks to aid in the procurement of plant materials needed to retain traditional medical praxis (Volpato et al. 2007). Ethnoecologists also consider traditional plant foods and medicines in their efforts to interpret health belief systems (Quave and Pieroni 2007). Ethnoecological studies also highlight the forces that continuously shape how information is transferred from one generation to the next (Nolan 1998; Zarger and Stepp 2004; Zent 1999).

Over the past decade, ethnobotanists have focused attention toward the survival of plant-based knowledge at its source—in local communities where it is rendered especially meaningful (Thompson 2004; Turner et al. 2008). Encouraging headway can also be seen through grassroots organizations such as CIBA (California Indian Basketweavers' Association), the Northwest Native American Basketweavers Association, and the Cherokee Native Plants and Arts Society in Oklahoma. These examples of contemporary ethnobotany in practice share a holistic and multidisciplinary approach that is increasingly necessary for the advancement of human wellbeing on multiple levels—physical, spiritual, nutritional, and emotional.

METHODS IN ETHNOBOTANY

Over the past 40 years, the scope of methods in ethnobotany used to assess relationships between people and plants has broadened significantly. The first task for many ethnobotanists is to develop a research question that can be investigated during a feasible period of time. Questions might be general, such as, “Which wild plant foods are consumed most frequently among the North Carolina Lumbee Indians?” Or they might be more specific, such as, “Why is river cane (*Arundinaria gigantea*) a culturally important plant species, threatened in the Cherokee Nation of Oklahoma?” Other questions extend or advance prior discoveries, for example: “What can Native or Indigenous communities do to protect culturally significant species from overexploitation in the Pacific Northwest?” Researchers often base their work on hypotheses, which can be tested by using one or more lines of evidence and methods.

Choosing a research site goes with the selection of questions the ethnobotanist seeks to answer. Students who are new to the field may begin their inquiry on a local level, which ensures affordable access to research settings, such as Native American communities in Canada, the United States, or Latin America, or traditional communities wherever the student may happen to live. Conducting fieldwork “locally” is valuable on two levels. First, it inspires appreciation for cultures and ecosystem conservation in the researcher's own homeland. Second, it provides ample opportunity for researchers to familiarize themselves with the toolkit of techniques they will use in future studies. Emerging ethnobotanists may develop interest in and commitment to other peoples and places through university seminars, field schools, and local cultural events that expose them to very different cultural and geographic settings.

Many ethnobotanical studies proceed through a technique known formally as participant observation, an approach commonly used among ethnographers who work with Indigenous peoples. This is a methodology in which ethnobotanists adopt the lives and daily routines of the people they wish to learn about. It entails participating in day-to-day activities, such as household chores, collecting water and fuel, helping out in the garden, or going fishing, hunting, or gathering and preparing food with community members. While offering a chance to develop rapport, friendship, and goodwill with others, participant observation yields obvious insights for ethnobotanists who seek to understand the meaning of plants in everyday life. Valuable personal experiences with people and plants can be documented, recorded, or videotaped (only with permission, of course) as they occur in context. Subtleties of people–plant interactions, when observed and examined in this manner, can lead to larger discoveries about local systems of plant cultivation, harvesting, fertilization, utilization, and management (cf. Turner et al. 2000; Deur and Turner 2005). By actually doing what local people do, the researcher learns much that is so “obvious” that local people would never think to mention it in interviews!

As a general rule, most community members, including children, know something valuable about ambient flora, whether wild, cultivated, or semi-cultivated (Zarger 2002). Therefore it is advisable to undertake an assessment of the full range of botanical knowledge existing within a population. One technique for identifying “experts” is to collect enough data to develop a consensus of intracultural agreement regarding the names of plants used frequently among members of a cultural group. These individuals, known as key respondents, represent the culmination of generations of expertise in their home communities. Of course it is important to remember that some individuals may have expertise in one area of ethnobotanical knowledge, and some in another. Men and women, for example, usually hold differing knowledge and experience in relation to ethnobotany (cf. Howard 2003). Consulting with key respondents, formally or informally, generates insights about the total constellation of plants known among a social group. They may convey messages about threatened species, once abundant but suddenly scarce, or the social forces deemed responsible for changes observed in species diversity and distribution. Important local priorities about natural resource conservation often emerge through repeated conversations with expert respondents. Other concerns regarding intellectual property rights may also become apparent through the course of rapport building (e.g., Bannister and Hardison, 2011; Brush 1996; Gilmore and Eshbaugh, 2011).

Community elders are frequently the bearers of the largest amounts of native plant knowledge. Other personal demographic factors are considered when respondents are sought out for consultation. Resident healers, for instance, are sometimes available and willing to share their wisdom. In instances when the healer provides the names and applications of therapeutic species, the ethnobotanist inquires about the respondent’s wishes regarding the dissemination of this valuable information. Ethnobotanists are responsible for the ethical management of all information entrusted to them. Cultural knowledge of plants is at once a personal and collective construction of knowledge, composed of peoples’ experience with plants and of the broader social understanding of what plants “mean” to those who use them in any society. Modernization can lead to erosion of knowledge among members of industrial societies and remote ethnic groups alike. New techniques for assessing ethnobotanical knowledge change have recently been identified (e.g., Zent and López-Zent 2004). Ethnobotany is thus capable of generating historical and ecological texts of people–plant interactions.

Ethnobotanists should, whenever possible, and with the permission of the community, collect “voucher specimens” of the plants they document through the interview process. For actual botanical identification and research, vouchers are *necessary*. Generally, collection is conducted under the supervision of expert respondents and, if required, with the collaboration of a translator. Voucher specimens aid the researcher in the scientific identification needed to confirm the alignment of folk names with scientific species of culturally significant taxa in a region. Most voucher specimens are recorded and catalogued for future reference, then dried, preserved, and deposited in a herbarium (see Martin 1995). It is often desirable to make duplicate collections, so that one set can remain in the community where the plants originated. Photographs are also helpful in this regard. *Since special permits are generally required when specimens cross national borders, ethnobotanists must consult with customs officials accordingly before they proceed.* Researchers can examine collections using novel microscopic, chemical, or genetic techniques. Thus, as new knowledge becomes available, the collections—together with the information recorded with them—become even more valuable as concrete representations in ethnobotanical knowledge systems.

Photographs of local flora can be useful reference tools for determining the distribution of plant knowledge among a community (Thomas et al. 2007). Ethnobotanists have

also employed model building in their collective studies of human–plant interactions. Reenactments and replicas of subsistence and food processing and other activities in archaeobotany have been fruitfully employed (Martin 1995), alongside multi-scale mapping, assessing disturbance regimes, controlled burns, and soil development as they relate to the agricultural sciences. Ethnobotanists borrow sophisticated tools of inquiry from quantitative biology, for example, in assessing the economic value of plant resources harvested in various sectors of Africa (Cunningham 2001). This entails the analysis of botanical commodities in the broader exchange market, and their relationships to social networks to determine how goods and benefits are distributed among community members. Such efforts become increasingly generative and collaborative, and thus call for multidisciplinary efforts from ecologists, conservation biologists, linguists, cartographers, statisticians, and economists, alongside local communities.

CLASSIC CASE STUDIES AND THEIR CONTRIBUTIONS TO ETHNOBOTANICAL PRAXIS

Intergenerational Research in Medical Ethnobotany

In 1979, ethnobotanist Daniel Moerman set out to examine the bioactivity of Native North American plant medicines as recorded by generations of ethnographers and ethnologists. Moerman's quest to demystify Native medicine would become a seminal work in medical anthropology (Moerman 1979). Moerman applied a simple regression analysis to determine whether Native American plant medicines are distributed randomly, as the "placebo effect" might suggest, or if they occur in potentially meaningful, statistically relevant patterns throughout the plant world. Moerman's effort pulled together many decades of folk pharmacology to reveal medical applications that transcend social, ethnic, and linguistic boundaries of Native North America. His subsequent publications advanced and confirmed these findings by identifying evolutionary properties that explain why families of medicinal plants, such as the rose (Rosaceae), bean (Fabaceae), and mint (Lamiaceae) families are prominent. These families produce alkaloids and other compounds with bioactive properties that serve as chemical defenses against insect predation. When prepared and administered to the patient in accordance with culturally prescribed traditions, certain species within these families are now known to render efficacious physiologic effects which, as Etkin (1993) asserts, are experienced by individuals in ways that are culturally constructed. More recently, ethnobotanist John Richard Stepp joined forces with Moerman to extend earlier findings regarding the distribution of medicinal species, many of which occur as weeds in disturbed forest regions (Stepp and Moerman 2001). Stepp (2004) also discovered that the weeds found within disturbed regions of ecosystems yield a higher proportion of pharmacologically active compounds than would be expected by chance. Stepp continues to generate innovative discoveries in medical ethnobotany through the application of Geographic Information Systems (GIS) technology to reveal regions of the world where cultural, linguistic, and ecological diversity correlate and overlap.

Using Paleoethnobotany to Understand the Past: Ötzi and Kwäday dän Ts'inchí

In paleoethnobotany—the ethnobotany of past human societies—chance discoveries often lead to amazing insights about how our ancestors lived. In 1991, a fully intact human

body was discovered melting from a glacier in the Tyrolean Alps, at the border of Italy and Austria, over 3200 m elevation. Named *Ötzi* after the Ötztal Alps where he was found, he died at around the age of 46 about 5200 years ago: the earliest intact human body known to date. Some time after he was found, an arrowhead embedded in his back under the left shoulder was detected, which had probably caused his death.

Then, in 1999, the body of a young man, probably in his late teens when he died, was discovered by hunters at the foot of a glacier in far northwestern British Columbia, in the upper Alsek River watershed in the Tatshenshini-Alsek Park, about 85 km from the seacoast just inland from Yakutat, Alaska. Named *Kwädäy dän Ts'inchí* (Long Ago Person Found) in the language of the Southern Tutchone, he had died approximately 550 years ago, from unknown causes (Beatty et al. 2000).

Who were these ancient mountain travelers? What were they doing when they died? How far, and from where, had they traveled? These key questions, and paleoethnobotany have played an important role in answering them, particularly through the work of James Dickson and his colleagues (Dickson et al. 2003, 2004). Studies of artifacts and visible plant, animal, and fungal remains, and microscopic examinations of pollen, moss fragments, silt and minerals, and other materials within their digestive tracts and in association with the bodies of these men have revealed important evidence, including of what they had eaten in the hours before their deaths, and where they had probably lived their lives.

Ötzi was found to have eaten the meat of ibex and red deer, cereal, and other plant food prior to his death. A whole array of belongings was found with him, including a number of artifacts of different woods: an axe with a yew wood haft and copper blade; an unfinished bow of yew wood (*Taxus baccata*), over 1.8 m long; arrows with shafts of the wayfaring tree (*Viburnum latana*), mostly unfinished; a dagger with an ash wood (*Fraxinus excelsior*) handle; and a pack frame of bent hazel wood (*Corylus avellana*). He was carrying sloe plums (*Prunus spinosa*) and two birch-bark vessels, one to carry embers. He had wrapped pieces of charcoal in fresh maple leaves (*Acer* sp.). He was carrying two kinds of fungus, *Fomes fomentariaus* and *Piptoporus betulinus*, possibly for tinder or medicine. His clothing was carefully fitted and stitched and included a cape with a grass weft and a warp of the bast fibers of lime, or basswood (*Tilia* sp.), and goatskin shoes with bearskin soles lined with grass. Over 80 species of bryophytes in *Ötzi*'s digestive tract and surroundings were identified by Dickson, and two of them, *Neckera complanata* and *N. crispa*, helped (along with the style of axe and his flints), to pinpoint his origin from South Tyrol, rather than from Austria. The pollen of hop-hornbeam (*Ostrya carpinifolia*) and hazel in his gut and other evidence indicated that he had died in early summer (Dickson et al. 2003).

The story of *Kwädäy dän Ts'inchí* is equally compelling. His belongings were of both coastal and interior origins: a sewn cape of interior style made from skins of Arctic ground squirrel (*Spermophilus parryi*), a species common only in the interior; and a twined spruce root hat (probably *Picea sitchensis*) of Tlingit style. A high proportion of the pollen in his stomach and intestine was of Chenopodiaceae, concluded to be that of glasswort, *Salicornia depressa*, a coastal marsh species whose pollen was also present on his ground squirrel cape. Cultural associations with this species were determined through ethnobotanical consultations with elders of Champagne-Aishihik, Tagish, Gwitch'in, and Tlingit First Nations (Mudie et al. 2005). This pollen, added to other evidence (i.e., a fruit of mountain sweetcicely *Osmorhiza berteroi*, and a needle of mountain hemlock, *Tsuga mertensiana*, pollen of Sitka spruce, *Picea sitchensis* and western hemlock, *Tsuga heterophylla*, and scales of four-year-old chum salmon, *Oncorhynchus keta*, all coastal species, on his cape; a fragment of *Sphagnum imbricatum*—a coastal bryophyte species, in his gut; and a skeleton fragment of a large crustacean from his stomach), indicate that he had been on the coast recently previous to his travels (Dickson et al. 2004). Bone and hair isotope data indicate

that he had lived on marine food, mainly fish and marine mammals, for most of his life, but had spent time inland for a few months before he died. These are just two of many examples of how ethnobotany contributes to our understandings of past human lifeways.

Solving the Mystery of a Notorious Illness: Ethnobotany and Cycad Toxicity

Sago palm (*Cycas revoluta*) and other cycads (*Cycas* spp.), sometimes called seed ferns, are commonly grown as house and greenhouse ornamentals, as well as outdoors in warmer areas. In some parts of the world—for example, Australia and the South Pacific—humans have used the seeds of cycads as a food source, but only after prolonged processing, since the raw seeds are known to be toxic. Various animals also consume cycad seeds, however. For example, flying foxes, large fruit-eating bats of the genus *Pteropus*, forage on the seeds of a tree cycad, *Cycas micronesica*. Knowing about cycad seeds as fruit bats' food enabled ethnobotanist Paul Alan Cox and his colleagues (Cox et al. 2003) to determine the cause of a deadly affliction of the Chamorro Indigenous People of the Pacific island of Guam.

The Chamorro population has suffered from a disease called ALS-PDC (amyotrophic lateral sclerosis/parkinsonism–dementia complex), which causes deterioration of the muscles and nervous system with effects similar to the well known “Lou Gehrig’s Disease,” at 50–100 times the average incidence in other populations throughout the world. Cox and his colleagues determined, first of all, that a major source of cycad toxicity originates not in the plants themselves, but in cyanobacteria (formerly known as blue-green algae). These organisms live in a symbiotic relationship in specialized coralloid roots of cycads and produce a non-proteinogenic amino acid called beta-methylamino-L-alanine (BMAA), which is highly toxic and particularly affects the nerves and spinal cord. BMAA is taken up by the host cycad and is concentrated in its seeds, especially in the outermost seed layer. These researchers determined that BMAA is further bioaccumulated when animals eat cycad seeds; flying foxes accumulate BMAA in their flesh at over twice the levels found in the cycad fruits. Finally, the researchers noted, fruit bats have been a prized food item of the Chamorro, who boil them in coconut cream and eat them whole. This practice, then, was identified as the source of the high incidence of neurodegenerative disease for the Chamorro. Cox et al. (2003) note that BMAA has also been found in the brain tissues of Alzheimer’s patients from Canada, suggesting alternative pathways for bioaccumulation of this compound in aquatic or terrestrial ecosystems. Nevertheless, one cause of the disease—linking toxins from cyanobacteria to people through cycads and fruit bats—is now determined, and this is a major breakthrough in our understanding of the risks and benefits of human food systems.

CONCLUSION

Ethnobotany started as a rather narrow and limited field of study, comprised initially of inventories of useful plants and their corresponding uses among Native peoples. Yet there is perdurability within people–plant relationships that has captured and maintained the attention of people from all walks of life, from all reaches of the world. Furthermore, what would appear as a simple and straightforward study of human–plant relationships expands to tell the stories of humans’ place in the world and their ties to each other. Historically, ethnobotany is a field of study defined by a merging of botany and ethnology. Like its parental disciplines, ethnobotany has evolved significantly since its inception, and is

serving new purposes in the twenty-first century. Environmental degradation and resource mismanagement, accompanied by an even more precipitous erosion of linguistic and cultural diversity, have fueled creative and progressive goals in the minds and hearts of ethnobotanists, whose work typically involves social concerns for sensible, sustainable, mutually compatible strategies to maintain cultural diversity and biodiversity for the benefit of present and future generations. More than ever before, collaboration and partnership are being promoted with Indigenous and local communities, and ethnobotanists have involved themselves in the struggle to preserve the integrity of both cultures and languages and the environments in which they are situated.

This supportive function will undoubtedly continue and strengthen in the coming years, as Indigenous peoples and local communities, governments, educators, non-government organizations (NGOs) and corporations all strive to address impending environmental degradation and cultural loss. It is a trend situated within the context of international imperatives to respect and support the rights and knowledge of Indigenous peoples worldwide. The Convention on Biological Diversity arising from the United Nations Conference on Environment and Development in Brazil (United Nations BDC 1992), and the Declaration on the Rights of Indigenous Peoples, which was adopted by the United Nations General Assembly in September 2007, contain explicit requirements for governments of Member Nations (including Canada and the United States) to respect the rights of Indigenous Peoples, and to consult and collaborate with them meaningfully in all aspects of resource use affecting their lands and territories. The Preamble to the Convention on Biological Diversity, for example, clearly recognizes the close interrelationships between Indigenous Peoples and their lands, and the critical importance of their environmental knowledge. It also recognizes the often overlooked but significant role of women as resource managers and keepers of traditional ecological knowledge.

Ethnobotanists have a major role to play at the community level, where objective approaches are especially valuable in data collection. They can also involve themselves in policy-making and legislation to ensure the recognition and protection of such knowledge. They can serve communities by providing vital information on scientific plant identification and broad-scale ecological knowledge, and by forging creative linkages to other communities with similar needs and goals of preserving and perpetuating cultural knowledge of plants and environments. They can participate in developing school and college curricula, audiovisual productions, science and cultural camp activities, museum exhibits, and locally relevant plant guides (e.g., Thompson 2004), and in establishing ethnobotanical gardens (Turner and Wilson 2006), and eco-cultural centers. They can contribute to local bioeconomic development such as sustainable harvesting of Non-Timber Forest Products (Cunningham 2001) or ecotourism ventures supported by local cultural and ecological knowledge. They can help to connect Indigenous and local communities with ethical partners for researching and marketing local products, and can also facilitate relationship building between local Indigenous peoples and other academics wishing to undertake collaborative research. They can also serve to corroborate, substantiate, and validate Indigenous knowledge in treaty and land rights negotiations (Turner 2004).

Harshberger's original concept of ethnobotany has been transformed many times over the past century, and ethnobotany in the twenty-first century promises to serve humanity well. As long as there is a need for original, careful, systematic, collaborative documentation of peoples' dynamic interactions with the plant world, for bridging social and ecological systems, for maintaining and enhancing biocultural diversity, and for reconnecting health and wellbeing with cultural and environmental integrity, ethnobotany will be a field of relevance and importance in the world.

REFERENCES

- ALCORN J. Huastec Mayan ethnobotany. Austin (TX): University of Texas Press; 1994.
- ALCORN J. Ethnobotanical knowledge systems: a resource for meeting rural development goals. In: WARREN DM, SLIKKERVEER LJ, BROKENSHA D, editors. The cultural dimension of development: Indigenous knowledge systems. London: Intermediate Technology Publications; 1995.
- ALEXIADES M, LAIRD S. Laying the foundation: equitable biodiversity research relationships. In: LAIRD S, editor. Biodiversity and traditional knowledge: equitable partnerships in practice. London, UK: Earthscan; 2002. p 3–15.
- ANDERSON MK. Native Californians as ancient and contemporary cultivators. In: BLACKBURN TC, ANDERSON MK, editors. Before the wilderness. Environmental management by Native Californians. Menlo Park (CA): Ballena Press; 1993a. p 151–174.
- ANDERSON MK. California Indian horticulture: management and use of redbud by the Southern Sierra Miwok. *J Ethnobiol* 1993b;11(1):145–157.
- ANDERSON EN. Ecologies of the heart: emotion, belief, and the environment. New York: Oxford University Press; 1996.
- ANDERSON EN. Maya knowledge and “science wars”. *J Ethnobiol* 2000;20:129–158.
- ANDERSON EN. Comments. In: FORD R, editor. Ethnobiology at the millennium: past promise and future prospects. Ann Arbor (MI): Museum of Anthropology; 2001. p 175–186.
- ANDERSON EN. Everyone eats: understanding food and culture. New York: New York University Press; 2005a.
- ANDERSON MK. Tending the wild: native American knowledge and the management of California’s natural resources. Berkeley: University of California Press; 2005b.
- ATRAV S, MEDIN D, ROSS N. Evolution and devolution of knowledge: a tale of two biologies. *J Roy Anthropol Inst* 2004;10(2):395–420.
- BALÉE W. Advances in historical ecology. Historical Ecology Series. New York: Columbia University Press; 1998.
- BALICK M. Ethnobotany: linking health and environmental conservation. In: CHESWORTH, J, editor. The ecology of health: identifying issues and alternatives. Thousand Oaks (CA): Sage Publications; 1996. p 201–209.
- BEATTIE O, APLAND B, BLAKE EW, COSGROVE JA, GAUNT S, GREER S, MACKIE AP, MACKIE K, STRAATHOF D, THORP V, TROFFE PM. The Kwáday Dän Ts’ínchi discovery from a glacier in British Columbia. *J Can d’Archéol* 2000; 24:129–147.
- BERLIN B. Speculations of the growth of ethnobotanical nomenclature. *Lang Soc* 1972;1:51–86.
- BERLIN B. Ethnobiological classification: principles of categorization of plants and animals in traditional societies. Princeton (MA): Princeton University Press; 1992.
- BERLIN B, BREEDLOVE DE, RAVEN PH. Folk taxonomies and biological classification. *Science* 1966;154: 275.
- BOSTER JS. Selection for perceptual distinctiveness: evidence from Aguaruna cultivars of *Manihot esculenta*. *Econ Bot* 1985;39(3):310–325.
- BROWN CH. Language and living things: uniformities in folk classification and naming. New Brunswick (NJ): Rutgers University Press; 1984.
- BRUSH SB. Whose knowledge, whose genes, whose rights? In: BRUSH B, STABINSKY D, editors. Valuing local knowledge: Indigenous people and intellectual property rights. Washington (DC): Island Press; 1996. p 1–24.
- BRUSH SB. Cultural research on the origin and maintenance of agricultural diversity. In: SANGA G, ORTALLI G, editors. Nature knowledge: ethnoscience, cognition, and utility. New York: Berghahn Books; 2004. p 379–385.
- CAMPBELL BC. Developing dependence, encountering resistance, and the historical ethnoecology of farming in the Missouri Ozarks [PhD Dissertation]. Athens (GA): Department of Anthropology, University of Georgia; 2005.
- CARLSON T, MAFFI L, editors. Ethnobotany and conservation of biocultural diversity. Advances in economic botany. Volume 15. New York: Botanical Garden Press; 2004.
- CASAGRANDE D. Conceptions of primary forest in a Tzeltal Maya community: implications for conservation. *Hum Organ* 2004;62(2):189–202.
- CONKLIN H. The relation of Hanunóo culture to the plant world [PhD Dissertation]. New Haven (CT): Yale University; 1954.
- COX PA, BANACK SA, MURCH SJ. Biomagnification of cyanobacterial neurotoxins and neurodegenerative disease among the Chamorro people of Guam. *Proc Nat Acad Sci* 2003;100(23):13380–13383.
- CUNNINGHAM A. Applied ethnobotany: people, wild plant use and conservation. London: Earthscan; 2001.
- DAVIS W. One river: science, adventure and hallucinogenics in the Amazon Basin. New York: Simon & Schuster; 1997.
- DAVIS W. Light at the edge of the world: a journey through the realm of vanishing cultures. Vancouver (BC) and Washington (DC): Douglas & McIntyre Press, and National Geographic Society; 2001.
- DEUR D, TURNER NJ, editors. Keeping it living: traditions of plant use and cultivation on the Northwest coast of North America. Seattle (WA) and Vancouver (BC): University of Washington Press, and UBC Press; 2005.
- DICKSON JH, OEGGL K, HANDLEY L. The Iceman reconsidered. *Sci Am* 2003;288(5):70–79.
- DICKSON JH, RICHARDS MP, HEBDA RJ, MUDIE PJ, BEATTIE O, RAMSAY S, TURNER N, LEIGHTON BJ, WEBSTER JM, HOBISCHAK NR, ANDERSON GS, TROFFE PM, WIGEN RJ. Kwáday Dän Ts’ínchi, the first ancient body of a man from a North American glacier: reconstructing his last days by intestinal and biomolecular analyses. *Holocene* 2004;14(4):481–486.
- DOUGHERTY J. Salience and relativity in classification. *Am Ethnol* 1978;5(1):66–80.
- ELLEN R, editor. Ethnobiology and the science of humankind. Malden (MA): Blackwell Publishing.

- ERTUG F, editor. Ethnobotany: at the junction of the continents and disciplines. Conference proceedings of the Fourth International Congress of Ethnobotany (ICEB 2005). Istanbul, Turkey: Yeditepe University, Yayinlari; 2006.
- ESTABROOK G. Maintenance of soil fertility in a traditional Portuguese agricultural system. *J Ethnobiol* 1998; 18(1):15–38.
- ETKIN NL. Ethnopharmacology: biological and behavioral perspectives in the study of Indigenous medicines. In: JOHNSON TM, SARGENT CF, editors. *Medical anthropology: contemporary theory and method*. New York: Praeger; 1990. p 149–158.
- ETKIN NL. Anthropological methods in ethnopharmacology. *J Ethnopharmacol* 1993;38:93–104.
- ETKIN NL. *Edible medicines: an ethnopharmacology of food*. Tucson: University of Arizona Press; 2006.
- FORD RI. Prehistoric food production in North America. *Anthropological Papers* 75. Ann Arbor: Museum of Anthropology, University of Michigan; 1985.
- FORD RI, editor. *The nature and status of ethnobotany*. *Anthropological Papers* 67. Ann Arbor: Museum of Anthropology, University of Michigan; 1994 (revised from 1978).
- FRITZ GJ. Paleoethnobotanical methods and applications. In: MASCHNER HDG, CHIPPINDALE C, editors. *Handbook of archaeological methods*. Walnut Creek (CA): Altamira Press; 2005. p 771–832.
- HARSHBERGER JW. The purposes of ethnobotany. *Bot Gaz* 1896;21:146–154.
- HOWARD P, editor. *Women and plants: case studies on gender relations in local plant genetic resource management*. London: Zed Books; 2003.
- HUNN ES. The utilitarian factor in folk biological classification. *Amer Anthropol* 1982;84(4):830–847.
- HUNN ES. *Nch'i-Wana: "The Big River"*. Mid-Columbia Indians and their land. Seattle: University of Washington Press; 1990.
- INGOLD T. Two reflections on ecological knowledge. In: SANGA G, ORTALLI G, editors. *Nature knowledge: ethno-science, cognition, and utility*. New York: Berghahn Books; 2004. p 301–311.
- JAIN SK. *Bibliography of Indian ethnobotany*. India: Scientific Publishers; 2002.
- JERNIGAN K. An ethnobotanical investigation of tree identification by the Aguaruna Jivaro of the Peruvian Amazon. *J Ethnobiol* 2006;26(1):107–125.
- JOHNS T. *The origins of human diet and medicine*. Tucson: University of Arizona Press; 1996.
- LEPOFSKY D, HEYERDAHL EK, LERTZMAN K, SCHAEPE K, MIERENDORF B. Historical meadow dynamics in southwest British Columbia: a multidisciplinary analysis. *Conserv Ecol* 2003;7(3):5.
- MAFFI L. Linguistic, cultural, and biological diversity. *Annu Rev Anthropol* 2005;29:599–617.
- MARTIN GJ. *Ethnobotany: a methods manual*. London: Chapman and Hall; 1995.
- MINNIS PE. Famine foods of the northern American desert borderlands in historical context. *J Ethnobiol* 1991;11(2):231–256.
- MINNIS PE, editor. *Ethnobotany: a reader*. Norman: University of Oklahoma Press; 2000.
- MINNIS PE, ELISENS W, editors. *Biodiversity and Native North America*. Norman: University of Oklahoma Press; 2000.
- MITHEN S. Ethnobiology and THE EVOLUTION OF THE HUMAN MIND. In: ELLEN R, editor. *Ethnobiology and the science of humankind*. Malden (MA): Blackwell Publishers; 2006. p 45–61.
- MOERMAN D. Symbols and selectivity: a statistical analysis of Native American medical ethnobotany. *J Ethnopharmacol* 1979;1(2):111–119.
- MOERMAN D. The medicinal flora of Native North America: an analysis. *J Ethnopharmacol* 1991;31(1):1–42.
- MOERMAN D. An analysis of the food plants and drug plants of Native North America. *J Ethnopharmacol* 1996; 52(1):1–22.
- MORAN K, KING SR, CARLSON TJ. Biodiversity prospecting: lessons and prospects. *Annu Rev Anthropol* 2001; 30:505–526.
- MUDIE PJ, GREER S, BRAKEL J, DICKSON JH, SCHINKEL C, PETERSON-WELSH R, STEVENS M, TURNER NJ, SHADOW M, WASHINGTON R. Forensic palynology and ethnobotany of *Salicornia* species (Chenopodiaceae) in northwest Canada and Alaska. *Can J Bot* 2005;83(1):111–123.
- NABHAN GP. *Enduring seeds: Native American agriculture and wild plant conservation*. Tucson: University of Arizona Press; 1989.
- NABHAN GP. *Coming home to eat: the pleasures and politics of local foods*. New York: W.W. Norton; 2002.
- NAZAREA V. *Cultural memory and biodiversity*. Tucson: University of Arizona Press; 1998.
- Nazarea V, editor. *Ethnoecology. Situated knowledge/located lives*. Tucson: University of Arizona Press; 1999.
- NOLAN JM. The roots of tradition: social ecology, cultural geography, and medicinal plant knowledge in the Ozark–Ouachita Highlands. *J Ethnobiol* 1998;18(2): 249–269.
- NOLAN JM. Wild plant classification in Little Dixie: variation in a regional culture. *J Ecol Anthropol* 2002;6(1):69–81.
- NOLAN JM. *Wild harvest in the heartland: ethnobotany in Missouri's Little Dixie*. Lanham (MD): Rowman and Littlefield; 2007.
- NOLAN JM, ROBBINS MC. Cultural conservation of medicinal plants in the Ozarks. *Hum Organ* 1999;58(1):67–72.
- PEACOCK S. "Putting down roots": root food production in the Canadian Plateau [interdisciplinary PhD dissertation]. Victoria (BC): University of Victoria; 1998.
- PEARSALL DM. *Paleoethnobotany: a handbook of procedures*. San Diego (CA): Academic Press; 2001.
- PIERONI A, PRICE LL, editors. *Eating and healing: traditional food as medicine*. Binghamton (NY): Haworth Press; 2006.
- PIERONI A, VANDEBROEK I, editors. *Traveling cultures and plants: the ethnobiology and ethnopharmacy of human migrations*. New York: Berghahn Books; 2007.

- PLOTKIN MJ. Tales of a Shaman's apprentice: an ethnobotanist searches for new medicines in the Amazon Rain Forest. New York: Penguin; 1993.
- PRANCE GT, BALÉE W, BOOM BM, CARNEIRO RL. Quantitative ethnobotany and the case for conservation in Amazonia. *Conserv Biol* 1987;1:296–310.
- QUAVE C, PIERONI A. Traditional health care and food and medicinal plant use among historic Albanian migrants and Italians in Lucania, Southern Italy. In: PIERONI A, VANDEBROEK I, editors. *Traveling cultures and plants: the ethnobiology and ethnopharmacy of human migrations*. New York: Berghahn Books; 2007. p 204–226.
- QUINLAN M. From the bush: the front line of health care in a Caribbean village. Belmont (CA): Wadsworth Publishing; 2004.
- QUINLAN M, QUINLAN RJ, NOLAN JM. Ethnophysiology and the herbal treatments of intestinal worms in Dominica, West Indies. *J Ethnopharmacol* 2002;80:75–83.
- RAMÍREZ-SOSA CR. Quantitative ethnobotany in El Salvador, Central America: a model to study ethnobotanical knowledge dynamics. *Proceedings of the IVth International Congress of Ethnobotany (ICEB 2005)*, 2006, 557–564. 2006.
- REA A. At the desert's green edge: an ethnobotany of the Gila River Pima. Tucson: University of Arizona Press; 1997.
- SALMÓN E. Kincentric ecology: Indigenous perceptions of the human–nature relationship. *Ecol Appl* 2000;10(5):1327–1332.
- SANGA G, ORTALLI G, editors. *Nature knowledge: ethnoscience, cognition, and utility*. New York: Berghahn Books; 2004.
- SCHULTES RE, HOFMANN A. *Plants of the gods: origins of hallucinogenic use*. New York: Van der Marck Editions; 1987.
- SHIPMAN AS, BOSTER JS. Recall, similarity judgment, and identification of trees: a comparison of experts and novices. *Ethos* 2008;36(2):171–192.
- STEPP JR. The role of weeds as sources of pharmaceuticals. *J Ethnopharmacol* 2004;92:163–166.
- STEPP JR. Advancements in ethnobiological field methods. *Field Meth* 2005;17(3):211–218.
- STEPP JR, MOERMAN DE. The importance of weeds in ethnopharmacology. *J Ethnopharmacol* 2001;75:21–31.
- STEPP JR, CASTANEDA H, CERVONE S. Mountains and biocultural diversity. *Mt Res Dev* 2005;23(3):223–227.
- THOMAS E, VANDERBROEK I, DAMME PV. What works in the field? A comparison of different interviewing methods in ethnobotany with special reference to the use of photographs. *Econ Bot* 2007;61(4):376–384.
- THOMPSON JC (EDOSDI). *Gitga'at Plant Project: the intergenerational transmission of Gitga'at plant knowledge and wisdom using school science curricula* [unpublished Master's thesis]. Victoria (BC): School of Environmental Studies, University of Victoria; 2004.
- TICKTIN T, NANTEL P, RAMÍREZ F, JOHNS T. Effects of variation on harvest limits for nontimber forest species in Mexico. *Conserv Biol* 2002;16(3):691–705.
- TIMBROOK J. *Chumash ethnobotany: plant knowledge among the Chumash people of southern California*. Santa Barbara (CA): Santa Barbara Museum of Natural History; 2007.
- TOBIN B. Biodiversity prospecting contracts: the search for equitable agreements. In: LAIRD S, editor. *Biodiversity and traditional knowledge: equitable partnerships in practice*, ed. Sarah Laird. London: Earthscan; 2002. p 287–309.
- TURNER NJ. *Plants of Haida Gwaii. Xaadaa Gwaay guud-gina k'aws (Skidegate), Xaadaa Gwaayee guugiin k'aws (Masset)*. Winlaw (BC): Sono Nis Press; 2004.
- TURNER NJ, WILSON B (Kiri'ILJUIUS). To provide living plants for study: the value of ethnobotanical gardens and planning the Qay'lnagaay Garden of Haida Gwaii. *Davidsonia* 2006;16(4): 111–125.
- TURNER NJ, IGNACE MB, IGNACE R. Traditional ecological knowledge and wisdom of aboriginal peoples in British Columbia. *Ecol Appl* 2000;10(5):1275–1287.
- TURNER NJ, MARSHALL A, THOMPSON JC (EDOSDI), HOOD RJ, HILL C, HILL E-A. “Ebb and flow”: transmitting environmental knowledge in a contemporary aboriginal community. In: LUTZ JS, NEIS B, editors. *Making and moving knowledge. Interdisciplinary and community-based research in a world on the edge*. Montreal and Kingston: McGill-Queen's University Press; 2008. p 45–63.
- VETETO JR, SKARBØ K. Sowing the seeds: anthropological contributions to agrobiodiversity studies. *Cult Agricult* 2009;31(2):73–87.
- VILDAIRICH A. Between bellyaches and lucky charms: revealing Latinos' plant-healing knowledge and practices in New York City. In: PIERONI A, VANDEBROEK I, editors. *Traveling cultures and plants: the ethnobiology and ethnopharmacy of human migrations*. New York: Berghahn Books; 2007. p 64–85.
- VOLPATO G, EMHAMED AA, SALEH SM, BROGLIA A, DILELLO S. Procurement of traditional remedies and transmission of medicinal knowledge among Sahrawi people displaced in southwestern Algerian refugee camps. In: PIERONI A, VANDEBROEK I, editors. *Traveling cultures and plants: the ethnobiology and ethnopharmacy of human migrations*. New York: Berghahn Books; 2007. p 245–269.
- ZARGER RK. *Children's ethnoecological knowledge: situated learning and the cultural-transmission of subsistence knowledge and skills among Q'eqchi' Maya* [PhD dissertation]. Athens (GA): Department of Anthropology, University of Georgia; 2002.
- ZARGER RK, STEPP JR. Persistence of botanical knowledge among Tzeltal Maya children. *Curr Anthropol* 2004;45(3):413–418.
- ZENT S. The quandary of conserving ethnoecological knowledge: a Piaroa example. In: GRAGSON T, BLOUNT B, editors. *Ethnoecology: knowledge, resources and rights*. Athens (GA): University of Georgia Press; 1999. p 90–124.
- ZENT S, LÓPEZ-ZENT E. Amazonian Indians as ecological disturbance agents: the Hoti' of the Sierra de Maigualida, Venezuelan Guayana. In: CARLSON TJS, MAFFI L, editors. *Ethnobotany and the conservation of biocultural diversity*. New York: New York Botanical Garden; 2004. p 37–78.

Chapter 10

Reconstructing Past Life-Ways with Plants I: Subsistence and Other Daily Needs

KAREN R. ADAMS

Crow Canyon Archaeological Center, Cortez, CO

SUSAN J. SMITH

Bilby Research Center, Northern Arizona University, Flagstaff, AZ

INTRODUCTION	150
METHODS	151
LARGER PLANT REMAINS	151
SMALLER PLANT REMAINS	151
FLOTATION SAMPLES	152
POLLEN SAMPLES	152
COMBINING ARCHAEOBOTANICAL RECORDS	157
CASE STUDIES AND EXAMPLES	157
SUBSISTENCE IN THE PAST	157
MAIZE IN STORAGE: A HUMAN TRAGEDY	158
FOODS THROUGH TIME AT SALMON PUEBLO	160
FOODS AND FARMING ON THE PAJARITO PLATEAU	161
POLLEN INDICATIVE OF BEVERAGES	161
THE TALES COPROLITES TELL	163
DOMESTICATION OR MANAGEMENT OF WILD PLANTS	163
PLANTS REFLECTING OTHER DAILY NEEDS AND ACTIVITIES	163
FUELWOOD AND BUILDING MATERIALS IN SOUTHWESTERN COLORADO	163
A MEDICINE PRACTITIONER'S RESOURCES	164

SMOKING MATERIALS IN PIPES AND CANE CIGARETTES	165
OTHER TOPICS	165
DISCUSSION	165
REFERENCES	166

INTRODUCTION

Before European contact, Native Americans depended on plant resources for shelter, food, tools, weapons, medicine, art, and religion. Even as New World Indigenous societies experienced profound changes associated with the Columbian Exchange (Mann 2005), they maintained an astounding knowledge of plants (Moerman 2003). Living elders on the Gila River Indian Reservation in Arizona have names for 150 distinct plant species (Rea 1997: 85), not including crop varieties, and know of at least 69 native edible plants (Rea 1997: 68). Deur and Turner (2005: 13) estimate the Native American cultures along the Pacific Northwest coast utilized 300 plant species. Anderson (2005: 242–244) suggests ancient California cuisines incorporated 1000 plant species and that these resources provided 60–70% of the primary staples for most tribes (see also Hammett and Lawlor 2004).

Our understanding of pre-Columbian North American subsistence is at an exciting juncture. It is only in recent decades that scientists have acknowledged the widespread and intensive management and cultivation of native plants (Adams 2004a; Anderson 2005; Blackburn and Anderson 1993; Boyd 1999; Deur and Turner 2005; Doolittle 2000). Models segregating Pre-Columbian subsistence modes into foraging, hunting-gathering, or farming are blurring (see B. Smith 2005) with increasing recognition that plant gathering and cultivation was often blended with hunting and foraging, creating “agroecosystems” (Deur and Turner 2005; Doolittle 2000). For example, the Kumeyaay Indians of southern California burned extensive areas to improve deer forage and remove competing plant species prior to broadcast seeding wild grass grains; they also transplanted and tended oak (*Quercus*), pine (*Pinus*), palm (*Washingtonia*), mesquite (*Prosopis*), agave (*Agave*), yucca (*Yucca*), wild grapes (*Vitis*), and cactus (Cactaceae) plants (Shipek 1989). In the southwestern United States, large-seeded and leafy native annuals, weeds, and grasses may have been semi-cultivated by 10,000 BP (Mabry 2005: 121). Maize (*Zea mays*) is a Mesoamerican cultigen evident in southwestern archaeological records by at least 2260 BC (Huber and Van West 2005). Other Mesoamerican domesticates, such as squash (*Cucurbita pepo*), amaranth (*Amaranthus cruentus*), and common beans (*Phaseolus vulgaris*), arrived independently between 1200 and 590 BC (Merrill et al. 2009).

The long-term legacy from human–environment interactions is imprinted in the modern composition of plant communities (see Pearsall and Hastorf, 2011). In the Southwest, cultivated transplants of cholla cactus (*Opuntia*; Housely 1974), agave (Hodgson 2001: 34–40), and sage (*Salvia*; Huisinga 1999) have been recognized in species range extensions or as isolated populations restricted to archaeological sites (see Adams 2004a: 190–192; Doolittle 2000: 71). In the Northwest, managed species recognized outside of their native range include camas (*Camassia quamash*), Garry oak (*Quercus garryana*), and wapato (*Sagittaria latifolia*; Deur and Turner 2005). Harder to discern are local extinctions of what may have been carefully tended subsistence plants (see Bohrer 1978).

Large-scale impacts such as deforestation may be preserved in the archaeological record (Adams 2004a). Easter Island archaeology pivots on the pollen record of human deforestation (Mann et al. 2008; but see Rull et al. 2010 for alternative theories). Telescoping to a global scale, Ruddiman (2005) presents compelling evidence that agriculture and accelerating human-caused environmental impacts linked to thousands of years of settled agricultural life have perturbed climate to the critical threshold of delaying the next glacial epoch.

In conjunction with information from artifacts and recovery contexts, archaeologists assemble multiple lines of evidence to suggest specific uses of plants in the past. In this chapter we discuss the methods involved in recovering large and small plant remains from archaeological contexts and present case studies and examples from the southwestern United States to demonstrate how botanical materials contribute to reconstructing past subsistence. There are also a number of synthetic reviews of the archaeological plant record to guide the reader into some of the archaeobotanical literature of the southwestern United States (see Adams and Fish 2005).

Documents written during the nineteenth and twentieth centuries provide general perspectives on historic plant uses, which are helpful in interpreting the archaeobotanical record (Bartlett 1951; Bell and Castetter 1941; Castetter 1935; Castetter and Bell 1942, 1951; Castetter et al. 1938; Doebley 1984; Havard, 1895, 1896; Palmer, 1870, 1878; Standley 1912; Stevenson 1915; Whiting 1939; Yanovsky 1936). In addition, books written by or for Native Americans provide invaluable perspectives on how they thought about and interacted with their environment (Thompson 1991 [1916]; Watt 2004; Wilson 1987 [1917]). These ethnobotanical records offer a rich reservoir of ideas about human needs satisfied by plants, and together the archaeological and ethnographic records often reveal long-term continuity in food choices and other daily needs (Adams and Fish 2006; Adams and Van West 2005). However, because plants may pass from favor among human groups, and because uses for a particular plant can change through time, the ethnographic record is incomplete as relevant to plant use through the ages.

METHODS

Larger Plant Remains

Macrobotanical samples include those plant remains large enough to be visible and collected during excavation. For decades, archaeologists focused on interpreting past subsistence and other needs for plants solely on the basis of these larger plant parts. However, these specimens tell only a portion of the story.

Smaller Plant Remains

Today smaller plant remains, among them seeds, fruits, fragments of charred wood, and fibers, are now routinely included in analysis. Other tiny remains include pollen grains (discussed here) and starch grains and phytoliths discussed by Pearsall and Hastorf (this volume). These plant materials are identified and described at various microscopic magnifications, and add significantly to the understanding of how plants were integrated into the lives of ancient groups. Some specimens are recovered by a water separation process called “flotation”. Pollen grains, phytoliths, and starch grains require chemical extraction procedures. Examples of how these microfossils contribute to our understanding of

human–environmental interactions, social relationships, and root and tuber use are discussed in Pearsall and Hastorf (2011).

Flotation Samples

Years ago, archaeologists realized that if they poured sediment into a bucket of water, buoyant plant remains would float (Bohrer 1970, 1986a). The charred and uncharred specimens that are skimmed from the surface and dried become the contents of a “flotation sample”. Archaeobotanists have compared and contrasted the wide range of flotation techniques reported by archaeologists (Wagner 1988: 17–35; Watson 1976: 77–100), but three general principles apply to a good flotation system: (a) cross-contamination between samples is minimized, so that the stories of plant use by an ancient group are not blurred; (b) the process is gentle, so that old and fragile specimens are not subjected to additional stresses; and (c) the process is relatively quick, so that plants parts do not have a chance to become waterlogged and sink.

As early as the 1970s, many large archaeological projects employed flotation to expand understandings of ancient plant use. Archaeobotanists at the Salmon Ruin in New Mexico published a book on their techniques and approaches (Bohrer and Adams 1977), as did archaeologists associated with other projects (Adams 2004b; Murray et al. 2008; plus others). Publications often include detailed criteria of plant part identification (Adams and Murray 2004a, b; Murray et al. 2008) and summarize information that provides links to historic uses of plants identified from archaeological sites (Rainey and Adams 2004; Adams et al. 2008). A comparison of some of the differences between charred plant remains from within structures versus those from middens is presented in Table 10.1. Some examples of archaeological plant remains are depicted in Fig. 10.1.

Pollen Samples

Pearsall and Hastorf (2011) discuss the paleoecological applications of pollen analysis. Here we introduce concepts and issues relevant to archaeopalynology (see also Bohrer 1981; Bryant and Hall 1993; Hevly 1981; Pearsall 2000). Sediment excavated from archaeological contexts is the most common type of sample analyzed, based on the assumption that pollen reflecting cultural plant use is preserved within site soils. Rinses from artifacts are another class of sample; however, artifact washes are not recommended except in extremely well protected contexts or unique situations due to the high risk of contamination (Geib and Smith 2008).

At less than 0.2 mm long, pollen grains come in a variety of three-dimensional shapes, displaying smooth, sculptured, folded, or etched surfaces, apertures ranging from simple holes or slits to complex systems of windows and furrows, and exterior elements like warts, spines and, in the case of the pines, twin bladders filled with air for flying in the wind (Fig. 10.2).

Archaeological pollen assemblages present interpretive challenges. One frustrating conundrum is that the *presence* of a pollen taxon may not reflect a local plant, whereas *absence* may mean a local plant was missed. This puzzle is, in part, related to plant pollination ecology. Anemophilous or wind-pollinated taxa, such as conifer trees, grasses, and sagebrush (*Artemisia*), are over-represented in fossil assemblages because they produce abundant aerodynamic pollen, which can travel up to hundreds of kilometers. In contrast, the entomophilous or insect-pollinated plants, such as cacti, most herbs, and some shrubs, produce small amounts of poorly dispersed pollen. After pollen grains fall to the ground

Table 10.1 Two Common Archaeological Contexts Where Seeds, Wood, and Other Small Plant Remains are Often Preserved

Context	Plant source areas	Time involved	Typical plant remains found
Structure floors and other contexts inside dwellings	Natural—being tracked in on sandals or fur of dogs; seeds/fruit carried in on twigs and branches sought for firewood; plant parts raining in on dwellings after they have been abandoned Cultural—deliberate gathering and use of plant materials, such as when cooking foods, making products for daily use (e.g., baskets, sleeping pads); suspending items from roof rafters as storage, including seeds for future planting, etc.	Duration of occupation might be short or long; the record of plant use is likely depicting the activities within the dwelling or family compound	Evidence of fuels used for cooking fires and to keep warm; foods prepared indoors; foods in storage for the future; discarded leftover materials from making everyday objects, including clothing; collapsed building timbers
Middens, other trash deposits	Natural—weedy plants that prefer disturbed habitats would occupy trash dumps and shed seeds and other parts into them, even as trash is being added Cultural—ashes cleaned from hearths and other thermal features and discarded into trash dumps contain evidence of fuels, foods, and other common plant uses	Middens may receive the debris from multiple families over multiple years; a generalized view of plant uses at a location over time is presented	The average daily choices people make for wood as fuel and for tools, seeds and fruit as foods, and other parts (leaves, stems, etc.) for a range of other daily needs

and become entrapped in sediment, complex biological and physical processes control their taphonomy and preservation (Berglund 1986; Dimbleby 1985; Fægri and Iversen 1989; Hall 1991; Moore et al. 1991). In addition to all the complex natural processes affecting pollen recovery, there are also methodological issues (see Pearsall 2000) dealing with sample collection (Bryant and Hall 1993; Cully 1979; Reinhard et al. 1992), laboratory techniques (Dean 1998; Smith 1998; Woolsey 1978), and interpretation (Bohrer 1981, 2007; Hevly 1981; Smith 2007: 532–534).

Most plant products utilized for subsistence, such as fruits, nuts, berries, seeds, roots and tubers, and leaves, are removed in space and time from their plant's pollen-producing flowers. Studies have shown that the amount of pollen retained by raw foodstuffs varies significantly (Bohrer 1972: 26; Geib and Smith 2008). Adams (1988) and Geib and Smith (2008) have shown that there is a component of "other" types of pollen from local plant communities that are attached to harvested food products and vegetal materials.

The best criteria for inferring ethnobotanical resources from archaeological contexts are when specific pollen taxa are more abundant than would be expected from natural pollen rain, and when pollen occurrence or abundance is patterned by context. Another interpretive

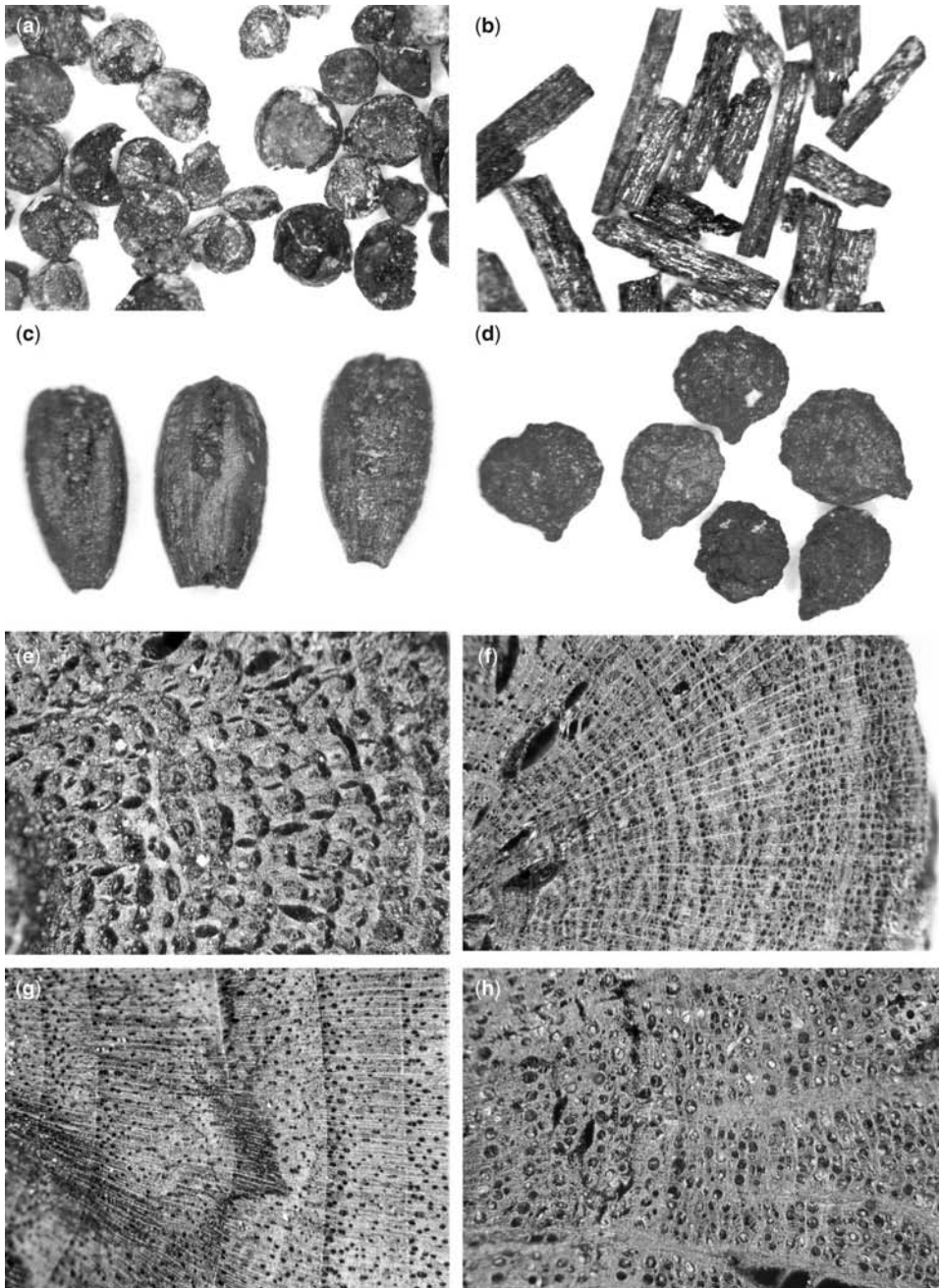


Figure 10.1 Some charred examples of archaeological non-wood specimens (a–d) and wood types (e–h). (a) Cheno-am seeds, representing goosefoot (*Chenopodium*) and/or pigweed (*Amaranthus*) seeds; (b) Agave (*Agave*) u-shaped fibro-vascular bundles with CaO (calcium oxalate) crystals; (c) domesticated little barley (*Hordeum pusillum*) grains (caryopses); (d) saltbush (*Atriplex*) fruit with bracts; (e) saltbush (*Atriplex*) wood; (f) mesquite (*Prosopis*) wood; (g) walnut (*Juglans*) wood; (h) oak (*Quercus*) wood. All photos at 20× magnification, except for the little barley grains (12×).

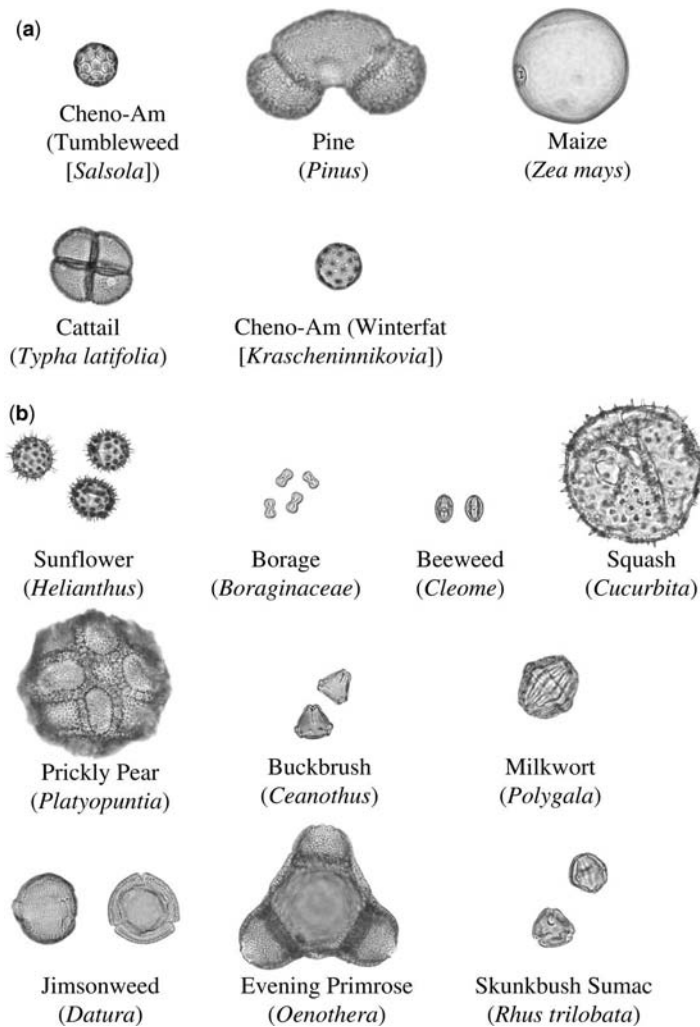


Figure 10.2 Examples of wind-pollinated (a) and insect-pollinated (b) pollen grains and common archaeological taxa.

tool is the consideration of pollen aggregates, which are clumps of the same pollen type (Bohrer 1981; Gish 1991: 238). Large and numerous aggregates in archaeological contexts are interpreted as evidence of human manipulation of plants, and their presence carries seasonal implications. A theoretical model for archaeological pollen taphonomy is presented in Table 10.2.

Even small numbers of pollen samples generate multivariate data sets that require numerical transformations to organize and comprehend patterning. Most archaeological pollen studies have relied on percentages to transform data. Percentages normalize sample pollen counts to 100 and each taxon is represented as a proportion of the total sum. One drawback is that the percentage of each pollen type is related to the numbers of other taxa. Pollen concentration is a different statistical tool; it estimates the absolute number of pollen grains per unit of sample sediment by weight or volume. This method allows each pollen type to be examined independently. Figure 10.3 demonstrates the differences between

Table 10.2 Theoretical Model of Pollen Taphonomy in Archaeological Sites

Context	Pollen source areas	Time involved	Typical pollen spectra and characteristics
Feature floors: includes structures, thermal and non-thermal pits	Natural—from atmospheric pollen rain and insects and wildlife entering feature (dead and alive) Cultural—deliberate import of plant materials adds pollen from the harvested plant plus hitchhiking pollen from plants surrounding the harvested resource. This extraneous component comes in on crop materials, as well as people, tools, and firewood. Interior pollen rain from roof thatch materials is another cultural source area	Duration of occupation	Spiky values but tend towards lower pollen concentrations; Chenopodium and other weedy taxa usually dominant; highest expression of subsistence pollen types
Fill	Natural—primary source is sheetwash from runoff funneled into depressions of houses, pits, and other structures. Aeolian deposition also occurs and may rework sediments Cultural—wallfall, rooffall, post-occupation use of feature depressions as middens, and reworked trash material from site footprint	No data. Relatively rapid, less than 50 (?) years; depositional events may be rapid, but are episodic	Low to high pollen concentrations; Chenopodium and other weedy taxa usually dominant
Modern surface sediment	Natural—there is an issue of <i>no modern analog comparable to prehistoric natural landscapes</i> ; modern woodlands and forests are unnaturally dense with less understory due to historic fire suppression and overgrazing	No data. Estimate 10 to 100 (?) years; relatively consistent accumulation rates	In woodlands and forests, high pollen concentrations, high percentages of conifer pollen, low percentages of weedy taxa and degraded pollen

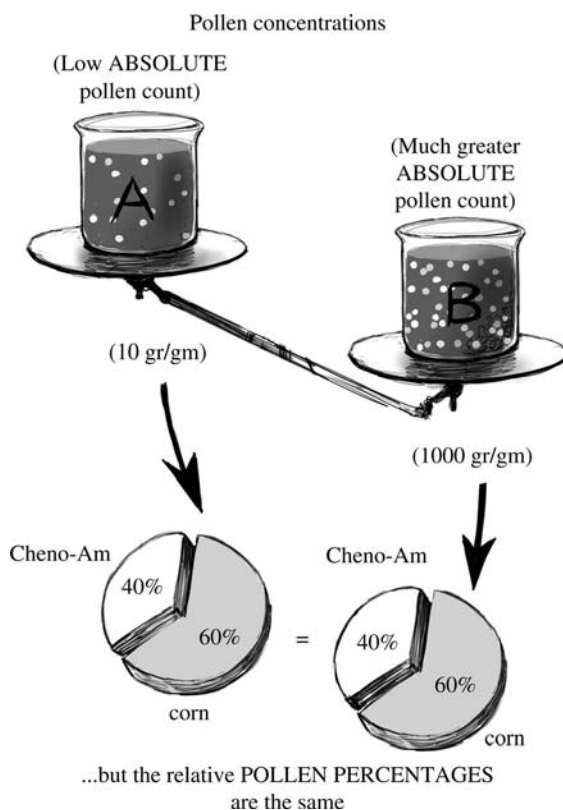


Figure 10.3 Pollen concentrations compared to percentages. Reproduced by permission of Bilby Research Center, Northern Arizona University. Victor Leshyk, artist.

percentages and concentrations (see also Birks and Gordon 1985: 11–16; Dean 1993; Reinhard 1993). The real power of pollen concentrations is as an index to compare plant abundance within and between sites.

Combining Archaeobotanical Records

The best archaeobotanical records are those that are supported by a range of plant sample types, since different records blend and complement each other to produce a better and more complete understanding of the role(s) that plants played in the lives of past groups. When flotation and pollen or other microbiological samples are collected from the same features within a site, chances increase for finding something indicative of activities associated with those features.

CASE STUDIES AND EXAMPLES

Subsistence in the Past

The relative reliance on animals and wild plants, in comparison to domesticated foods, is often an important arena of archaeological study. Subsistence mode influenced whether

ancient groups were sedentary, mobile, or some combination of the two, and impacted many aspects of daily life. To understand subsistence, archaeologists focus on food production, preparation, consumption, and storage. Plant evidence, animal evidence, and contexts of recovery of these remains are all important components, which must be integrated for the most complete subsistence interpretations.

Although the archaeological plant record reveals much about past foods, it may be skewed. Many plant parts have preserved because they became charred during food preparation. Once burned, these fragments are no longer of interest to degrading organisms and are likely to preserve. In contrast, any plant resource not routinely prepared by fire might have fewer chances to preserve. Fruits eaten raw are in this category. Likelihood of preservation also varies notably among different plants and their parts. Hard and sturdy plant parts, such as nutshells or seeds, have a better chance of surviving than fragile leaves or fleshy roots and tubers. Foods that have waste products that serve a secondary purpose, such as when maize cobs provide a fuel or tinder source, increase the chances of leaving evidence that possibly inflates their perceived importance.

Because many archaeological sites are exposed to the elements, it is reasonable to assume that their plant records are incomplete. This is well illustrated by the AD 520 Quemado Alegre site in New Mexico, where a catastrophically burned pithouse preserved an extensive array of basketry, ceramic, and gourd vessels with domesticated and wild food contents intact (Toll and McBride 1996). This assemblage offered a realistic assessment of the quantities of foods that a family might have in storage at a given moment. It also contrasted sharply with most regional archaeological plant records where poor preservation conditions left little evidence of agricultural and wild plant resources.

Maize in Storage: a Human Tragedy

Along the Santa Cruz River in Arizona, the Duval Mine Site was a Hohokam farmstead between AD 1000–1150 (Adams, forthcoming). It appears that local farmers grew maize on nearby floodplain and *bajada* fields, and at times harvested enough to store in underground storage pits outside their dwellings. One bell-shaped storage pit preserved intact a complete assemblage of charred contents (Fig. 10.4).

The storage pit measured 1.9 m in diameter at its base and 1.5 m in depth. This feature contained a charred assemblage that included: a thick layer of narrow grass stems at the pit bottom; maize kernels that filled the pit completely; ceramic scoops for removing kernels; a top protective covering woven from beargrass (*Nolina*) stems; and a layer of dirt to seal the pit.

Excavators calculated that the pit contained approximately 950 liters of Chapalote type popcorn kernels, which had been removed from the cob and stored for future use. This landrace of maize is still grown today by Indigenous groups, and has a long history in the American Southwest (Adams 1994). Following pit sealing, spontaneous combustion apparently destroyed the pit contents, either because the kernels had not been sufficiently dried prior to storage, or because floodwaters percolated down from the ground surface. Evidence for spontaneous combustion includes the near absence of kernel distortion, suggesting that kernels charred slowly, rather than rapidly. Spontaneous combustion occurs when moisture fosters bacterial or fungal growth, and increased respiration produces heat, which accumulates and cannot escape (Bala 1997; Nash 1985).

This unique pit allowed calculation of the amount of food in storage when the maize kernels combusted. An estimate of kernels/liter suggested that approximately 4 million kernels had been placed into storage. Modern Chapalote maize ears average 273 kernels/ear,

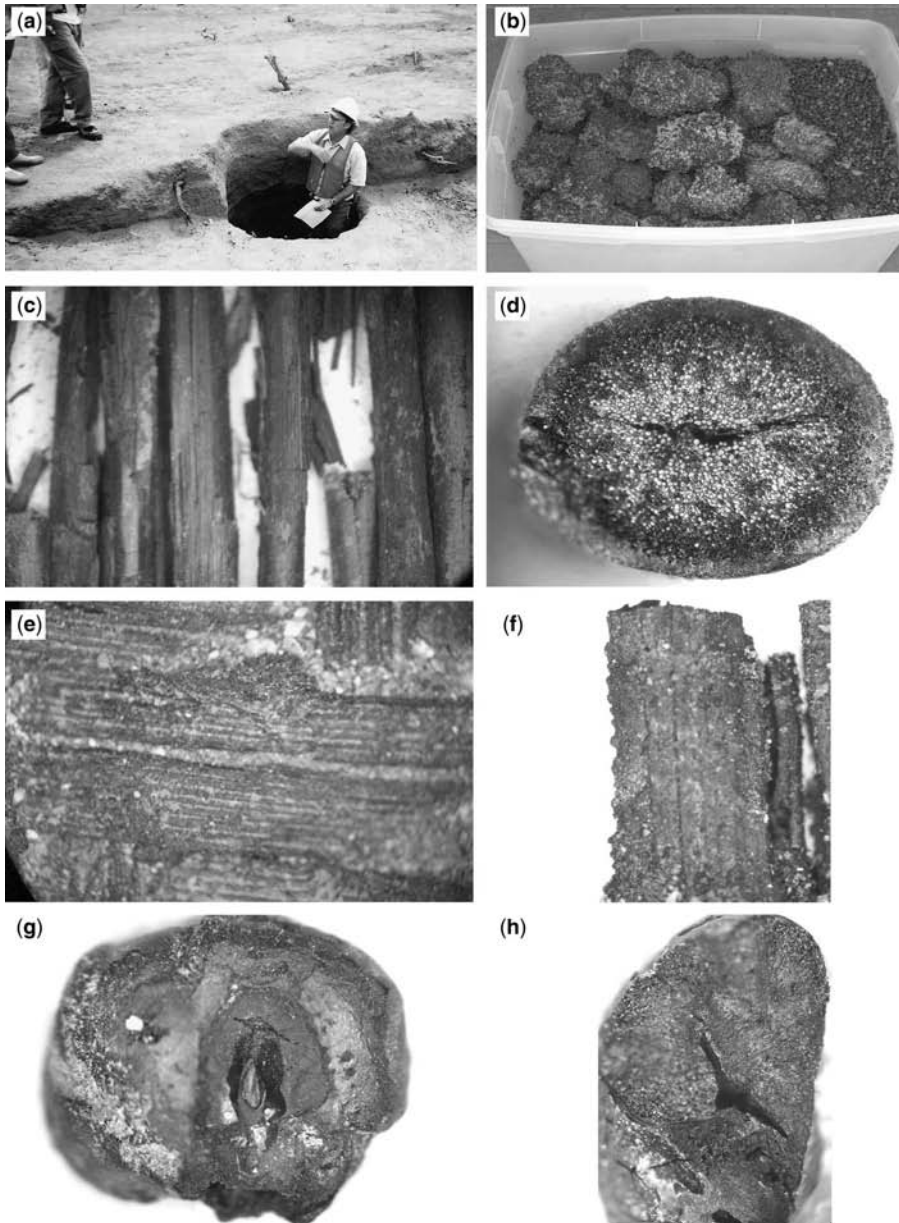


Figure 10.4 Duval Mine storage pit. (a) Pit with archaeologist Robert Neily inside; (b) a portion of the burned maize (*Zea mays*) kernels recovered from the pit; (c) charred grass (*Poaceae*) stems lined the pit bottom; (d) a charred grass stem in cross section; (e) mat woven of beargrass (*Nolina*) stems covered the pit opening; (f) small teeth on the edge of beargrass stems; (g) charred maize kernel; (h) section of maize kernel showing dense endosperm typical of popcorn.

so the Duval Mine kernels represent approximately 14,652 ears of maize. A study of Indigenous maize varieties (Adams et al. 2006) reported that maize landraces similar to Chapalote average 70.1 g of kernels per ear, suggesting the Duval Mine storage pit contained 513.6 kg of stored maize. Ethnographic estimates suggest that 160 kg of maize kernels were

desired per person per year (Van West 1990). Thus, the Duval Mine bell-shaped pit contained maize to feed approximately 3.2 people, or the equivalent of a single small family for a year. Considering the maize cache was completely lost, this event was presumably devastating for the family that owned the pit.

Foods Through Time at Salmon Pueblo

The subsistence record of people occupying Salmon Pueblo is well supported by plant parts preserved in hundreds of flotation samples (Adams 2006, 2008). Salmon Pueblo was built along the San Juan River in northern New Mexico, beginning around AD 1090, by a group with ties to Chaco Canyon. This group occupied the pueblo for several decades until a regional drought made life difficult (Van West and Dean 2000). By the early AD 1200s, another group took up residence, remodeling the pueblo and using different pottery types, until they left the pueblo in the late AD 1200s. Excavations produced a substantial database of plant materials collected using standardized methods and techniques (Bohrer and Adams 1977). A range of published resources (noted in Adams 2008) contribute to this case study, which compares and contrasts the subsistence choices of the two groups that lived in the same place, but with their occupations separated by a 50-year gap.

Domesticated plants were of major importance in the diets of both the early Chacoan and later Salmon Pueblo occupants (Adams 2008). Throughout the pueblo's history, farmers grew maize, beans (*Phaseolus*), and squash (*Cucurbita*). Maize parts included cobs, ears, husks, kernels, stalks and tassels. However, the evidence suggests the early Chacoan occupants focused more heavily on maize than the later occupants (Table 10.3). The presence of

Table 10.3 Some Evidence of Subsistence Differences Between Two Different Occupations of Salmon Pueblo

	Early (Chacoan) occupation	Later occupation	References
Maize presence within trash strata	77% (in 10 of 13 trash strata)	57% (in 13 of 23 trash strata)	Bohrer and Doebley 2006; Doebley and Bohrer 1983
Number of wild foods	19 wild plants utilized (in 14 trash strata)	28 wild plants utilized (in 17 trash strata)	Doebley 1976, 2006
Most commonly recovered wild foods	<i>Chenopodium-Amaranthus</i> on 6 (of 6) floors and in 13 (of 13) trash strata; <i>Portulaca</i> on 6 (of 6) floors, and in 9 (of 13) trash strata	<i>Chenopodium-Amaranthus</i> on 22 (of 22) floors and in 22 (of 23) trash strata; <i>Portulaca</i> on 17 (of 22) floors and in 18 (of 23) trash strata	Adams 2006
Ratio of domesticated squash seeds to wild juniper seeds	16.12 (in 8 trash strata)	3.59 (in 11 trash strata)	Lentz 1979
Evidence of starvation resources in human coprolites		Juniper bark, yucca leaves, maize cob fragments	Bohrer and Adams 2006

maize in 77% of flotation samples from Chacoan trash layers contrasts with its presence in 57% of trash deposits from the later occupation. In addition, the plant record indicated that the later occupants gathered a wider variety of wild plants, particularly weedy annuals of agricultural fields such as goosefoot (*Chenopodium*), pigweed (*Amaranthus*), and purslane (*Portulaca*). The later occupants also ate what might be considered starvation resources, such as juniper (*Juniperus*) bark, yucca (*Yucca*) leaves, and maize cobs. These data suggest that, despite living in exactly the same place, later occupants relied less on agricultural crops and more on wild plants, and had a difficult time getting enough to eat.

Foods and Farming on the Pajarito Plateau

Los Alamos National Laboratory Land Conveyance and Transfer (LC&T) project was an ambitious investigation of 38 sites on the Pajarito Plateau in New Mexico (see Vierra and Schmidt 2008). Including supporting studies and peripheral projects, 595 pollen samples were collected, processed, and analyzed by the same personnel ensuring consistent field and laboratory methods. Samples were taken primarily from pueblo room blocks and field houses dating to the Coalition (AD 1150–1325) through Classic periods (AD 1325–1600). Archaeobotanical data from pollen and flotation samples show that maize, squash, cholla, tobacco (*Nicotiana*), and cotton (*Gossypium*) were cultivated in addition to possible management of weedy plants such as purslane (*Portulaca*), goosefoot (*Chenopodium*), pigweed (*Amaranthus*) and grasses.

The Los Alamos pollen data illustrate how pollen concentration data can be used to explore subsistence research themes. Average measures of pollen concentration clearly differentiate more intensely occupied room blocks from field houses (Table 10.4). Smith (2007) interpreted the results to show that Puebloan room block sites with evidence of extensive remodeling and ground disturbance produced mixed pollen records, but that limited seasonal use of 21 field houses produced a particularly coherent chronological history of agricultural intensification by the Classic period (Fig. 10.5). Increased areas under cultivation at Classic period field houses is interpreted from the higher pollen concentrations of field weeds, such as Cheno-Am and beeweed, and maize pollen, compared to earlier Coalition period sites.

Pollen Indicative of Beverages

Archaeological evidence of beverages is usually inferred from the types of vessels recovered at sites. A recent surprising case is evidence for the ceremonial use of cacao (*Theobroma*

Table 10.4 Comparison of Pollen Concentrations from Floor Samples: Field Houses Compared to Room Block Rooms from the LC&T Project, Los Alamos

	Field houses	Room blocks front rooms	Room blocks back rooms
Number of sites	19	3	3
Number of houses or rooms	21	9	10
Number of floor samples	46	30	27
Average floor area, m ² (field house or room)	3.9	10.3	5.0
Average pollen concentration, grains/g	1917	5423	4324
Average pollen taxa richness	10.8	11.8	11.7

From Smith (2007).

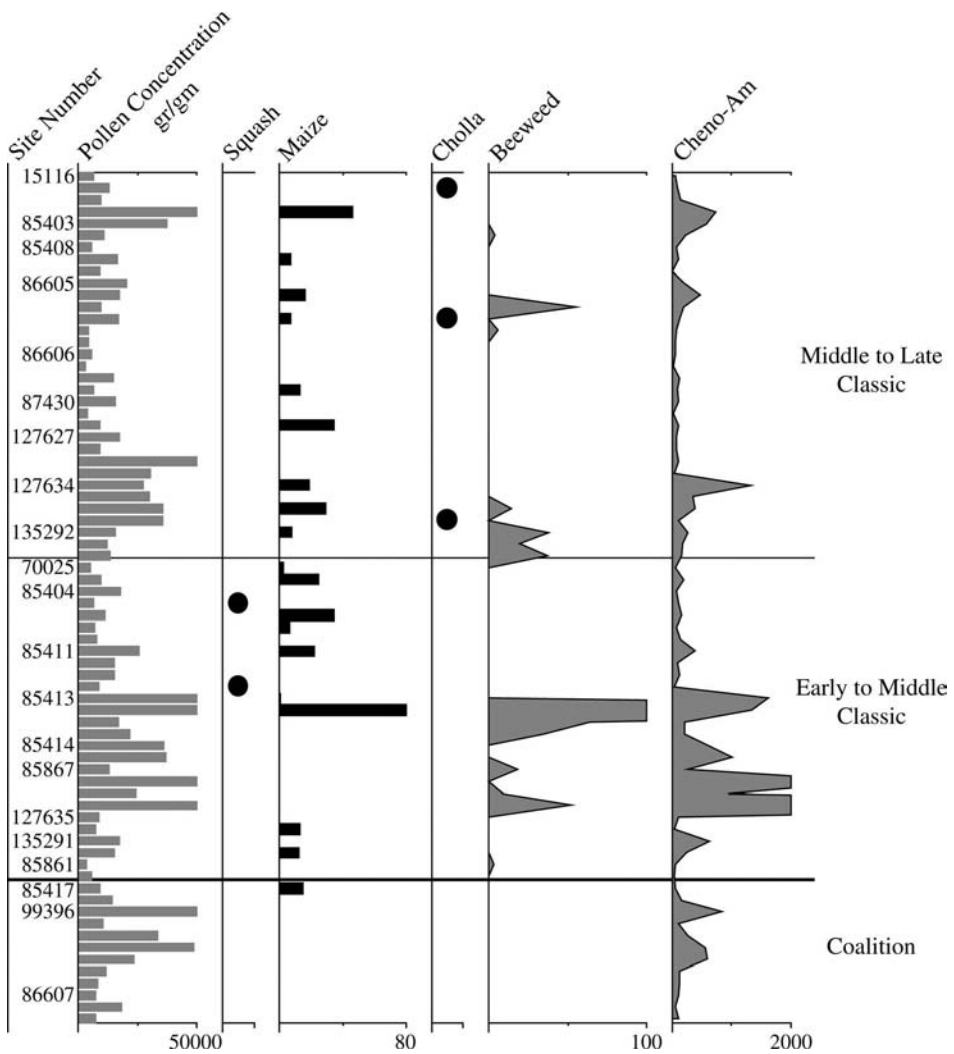


Figure 10.5 Pollen spectra from Los Alamos Rendija Canyon Coalition to classic field houses.

cacao) or chocolate at Chaco Canyon, New Mexico, AD 1000–1125 (Crown and Hurst 2009), revealed by analysis of powdered fragments from the interior of black-on-white painted pottery cylinder jars using high performance liquid chromatography (HPLC), coupled with spectral analysis.

Pollen has been used successfully to examine brewing techniques and recipes in alcoholic beverages. Rösch (2005) presents two studies: the first from organic material on a bronze ladle from a female burial (late Hallstatt/early La Tène) in Niedererlbach, Germany; and the second from residues from wine amphorae collected from early Medieval (fourth to early seventh centuries) hermitages and a church along the Nile River, middle Egypt. The pollen assemblages indicated the bronze ladle was used with mead and the Egyptian amphorae for wine, but high frequencies of mustard (*Brassicaceae*) pollen in the amphorae samples suggested that honey was added to increase the alcohol content or to make a sweet wine. Rösch (2005) also determined that the Egyptian honey was from “yield honeys”

characteristic of deliberate bee keeping, but the diversity of pollen taxa from the bronze ladle indicated mead made with wild honey.

The Tales Coprolites Tell

Excrement fossils from human feces or coprolites are a biological goldmine for investigating ancient diets and are preserved only in specific situations, such as dry caves and arid environments. Microscopic and macroscopic materials extracted and interpreted from coprolites include hair, feathers, bone, shell, scales from both fish and reptiles, insects, phytoliths, starch grains, pollen, seeds, and leaves (Bryant and Dean 2006; Reinhard and Bryant 1992).

Pollen from coprolites has been interpreted to reflect direct consumption of flowers or pollen from plants such as cacti, maize, squash, yucca, mesquite, cattail, and beeweed (Bryant 1974; Martin and Sharrock 1964; Reinhard et al. 1986; Sobolik 1988; Williams-Dean 1986). Wild seeds and domesticated crops reveal the variable and relatively healthy diets of ancient folks (Minnis 1989; Stiger 1977, 1979; Sutton and Reinhard 1995; Williams-Dean 1978). Intestinal parasites and pathogens preserved in coprolites also provide a perspective on the health of ancient people (Reinhard and Bryant 2008).

Coprolites have preserved some of the oldest human DNA from the western United States (14,200 years old; Gilbert et al. 2008). In addition, DNA within coprolites identifies both plant and animal components in human diets (Bryant and Dean 2006). Near Cortez, Colorado, evidence of cannibalism has been interpreted from coprolites dating to ca. AD 1150 (Billman et al. 2000; but see critique by Dongoske et al. 2000; Reinhard and Bryant 2008: 213–214).

Domestication or Management of Wild Plants

Although it once seemed that Mesoamerican domesticates were the main crop plants grown by ancient farmers, stories of domestication or management of wild plants are now emerging. Based on plant remains and other types of archaeological evidence, it is apparent that pre-Hispanic groups in the Sonoran Desert planted fields of agave (*Agave*) plants (Adams and Adams 1998), Little Barley grass (*Hordeum pusillum*; Adams 1987), and likely a number of other native plants (Bohrer 1991).

Plants Reflecting Other Daily Needs and Activities

Although subsistence is the most important reason people gather plants, plants also provide a wide range of resources for everyday needs. Some examples are discussed below. Other important reasons ancient people gathered plants are referenced in Table 10.5.

Fuelwood and Building Materials in Southwestern Colorado

Trees and shrubs offer human groups both fuels and building materials. The longer a group lives on a landscape, the more likely they might diminish preferred woods through frequent gathering. Two studies in southwestern Colorado reveal differences in impacts on local forests within a small region. Researchers at the Dolores Archaeological Project evaluated impacts on piñon (*Pinus edulis*)/juniper (*Juniperus osteosperma*) woodlands during the Ancestral Pueblo I (AD 720–910) period (Kohler and Matthews 1988). Focusing on hearths and other thermal features, archaeologists noted a reduction in piñon and juniper wood

Table 10.5 Examples of Other Important Kinds of Information Available from Archaeological Plant Remains

Products	Plant part(s)	References
Everyday items		
Sandals	Yucca leaves	Hovezak and Geib 2002
Sandals	10,000-year-old sagebrush bark sandals from Fort Rock, Oregon	Bedwell and Cressman 1971
Pottery paint	Beeweed (<i>Cleome serrulata</i>) plants	Adams et al. 2002a
Cordage	Juniper bark	Hovezak and Geib 2002
Basket	Possible rose family (<i>Rosaceae</i>)	Geib and Jolie 2008
Basketry elements	Fruit of devil's claw (<i>Proboscidea</i>) managed (historic period)	Nabhan et al. 1981
Ceremonial needs		
Blessings	Maize pollen	Bohrer 2006
Containers and ritual items (the magician's grave)	Wooden cups, wands, and other burial goods	McGregor 1943
Ritual artifacts (Chaco Canyon)	A wide range of carved and painted wooden items	Vivian et al. 1978
Split twig figurines	Willow	Hovezak and Geib 2002
Hallucinogen	Datura	Huckell and Vanpool 2006
Hallucinogen (and possibly medicinal)	Four o'clock (<i>Mirabilis</i>) roots	Bohrer 2007
Funerary offerings	Maize pollen	Smith 2007: 568
Offerings at shrines	Cotton caches	Anonymous 1964; Huckell 1993

remains, and an increase in wood from shrubs and plants of disturbed habitats. They concluded that the Pueblo I occupants altered their immediate environment by burning and clearing vegetation, and by intensively harvesting wood for both fuel and construction elements such as roofing timbers and roof/wall supports. Archaeobotanists working a short distance away came to a different conclusion when examining charred wood fragments from later Pueblo III period sites spanning the AD 1180–1290 period (Adams and Bowyer 2002). In that area, fuel wood diversity appeared relatively stable through the late twelfth and thirteenth centuries, with no major shifts in the top-ranking woods (piñon and juniper) through time or between pueblos. In addition, the presence of smaller parts such as bark scales, twigs, leaves, and needles suggested living trees remained within walking distance, despite an increasing human population. An examination of construction timbers revealed that Puebloans re-used intact roof beams and also cut new beams from the piñon/juniper forest. These two studies from one small region, each reaching a different conclusion, indicate the variability that exists in archaeological plant records, and caution against broad generalizations based on single projects.

A Medicine Practitioner's Resources

In a study of two AD 1700s medicine baskets found in a dry shelter in the Gallisteo Basin, New Mexico, Toll and McBride (1996) documented 14 root types that included osha (*Ligusticum porteri*), iris (cf. *Iris missouriensis*), dock (*Rumex*), and possibly datura

(*Datura*) and gayfeather (*Liatris punctata*). Other materials in the baskets were stems and leaves of grasses and silvery scurfpea (*Psoralea argophylla*), a maize husk container, ties made from maize leaves and yucca strips, and bark pieces of corkbark fir (*Abies lasiocarpa* var. *arizonica*), ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menziesii*). These assemblages preserve a perspective on a traditional medicinal plant tool kit that is practically invisible in the archaeological record, since root resources rapidly degrade and pollen is not expected from roots and tubers. Other examples of likely medicinal uses of plants in ancient times include a pollen grain of datura (*Datura*) preserved within Arroyo Hondo (Bohrer 1986b: 204), and medicinal use of Mormon tea (*Ephedra*) and possibly mesquite by occupants of an Archaic-age cave in western Texas (Sobolik and Gerick 1992).

Smoking Materials in Pipes and Cane Cigarettes

Minute samples of dottle (charred residue from smoking) from two clay pipe fragments produced odd pollen assemblages (Smith 2006: 220). The pipe was found in the fill above a kiva at a Coalition Period (AD 1150–1325) room block near Los Alamos, New Mexico. Both samples were tiny, weighing less than 2.0 g, yet pollen concentrations were extremely high at 47,591 and 28,527 grains/g, and between 30% and 40% of the recovered pollen was maize and probable tobacco. Flowering maize tassels or a wad of maize pollen may have been added to tobacco and smoked, a rare glimpse into a ceremonial practice.

In the AD 1325–1400 period, groups occupying Red Bow Cliff Dwelling, Arizona, fashioned cigarettes from reedgrass (*Phragmites australis*) stems to smoke a native tobacco (*Nicotiana attenuata*; Adams 1990). Distinctive anatomical and morphological details of the large grass and wild tobacco stems supported identification of both the cigarette and its contents. Many pre-Hispanic groups in the southwestern U.S. smoked tobacco (Adams and Toll 1989). The historic record of tobacco use and management among native southwestern U.S. communities (Winter 2000) suggests that smoking was often associated with ritual activities.

Other Topics

Pollen and larger plant remains have been used to study many topics diverse from daily subsistence and other needs. These include prehistoric agricultural fields (Fish 1984, 1994, 2004; Gish 1993a; Smith 2009), canals and other water control features (see Adams et al. 2002b), and reservoirs (Bayman et al. 1997). These also include historic latrines (Gish 1993b; S. Smith 2005; Smith and samples from construction mortar (Adams 2004c; O'Rourke 1983; Reinhard et al. 1986; Smith 2004).

DISCUSSION

The archaeological plant record sheds light on a wide range of topics. Whether plant parts are large enough to be collected during excavation or tiny enough to require specialized extraction techniques, independently and together they provide a window into ancient subsistence and the many reasons people have gathered plants through time.

Archaeobotany straddles the worlds of archaeology and botany, and training in both disciplines is important. As a botanist, familiarity with plant anatomy, morphology, and ecology can be valuable for identifying ancient plant parts with confidence, and then interpreting their significance. As an archaeologist, understanding archaeological methods/techniques, and the circumstances of each individual site, informs the process of interpreting the plant

record. The aim is to understand past human behavior, but there are circumstances that can blur the record of plant usage, among them: preparation methods that either foster or retard the likelihood of a plant entering the archaeological record; differential preservation of individual plant parts; differential preservation conditions at different archaeological sites; the natural rain of pollen grains and other plant parts into households, communities, and archaeological sites; and differences in site sampling and sample processing. These issues apply to both the larger and smaller archaeological plant remains discussed in this chapter.

The accumulating archaeobotanical record suggests that two critical ethnobiological principles have continued to operate through time: biodiversity and sustainability. Ancient hunter-gatherers sought a wide range of plants and animals for food and daily needs. Agriculturalists often continued to gather diverse wild plants, even as they concentrated on domesticated crops. When a farming group shifted to heavy reliance on crop plants, problems may have developed. However, it is clear that many landscapes have hosted human groups for millennia, at least intermittently, and sometimes continuously. The archaeological plant record plays a major role in understanding how this was possible.

REFERENCES

- ADAMS KR. Little barley (*Hordeum pusillum* Nutt.) as a possible New World domesticate. In: KISSELBURG JE, RICE GE, SHEARS BL, editors. La Ciudad, specialized studies in the economy, environment and culture of La Ciudad. Part III. Anthropological Field Studies nr 20. Tempe: Arizona State University; 1987. 203–237.
- ADAMS KR. The ethnobotany and phenology of plants in and adjacent to two riparian habitats in Southeastern Arizona [PhD dissertation]. Tucson: University of Arizona; 1988.
- ADAMS KR. Prehistoric reedgrass (*Phragmites*) “cigarettes” with tobacco (*Nicotiana*) contents: a case study from Red Bow Cliff Dwelling, Arizona. *J Ethnobiol* 1990; 10(2):123–139.
- ADAMS KR. A regional synthesis of *Zea mays* in the prehistoric American Southwest. In: JOHANNESSEN S, HASTORF CA, editors. Corn and culture in the prehistoric New World. Boulder (CO): Westview Press; 1994. 273–302.
- ADAMS KR. Anthropogenic ecology of the North American Southwest. In: MINNIS PE, editor. People and plants in ancient western North America. Washington (DC): Smithsonian Books; 2004a. 167–204.
- ADAMS KR. Archaeobotanical analysis: principles and methods; 2004b. Available at http://www.crowcanyon.org/ResearchReports/Archaeobotanical/Principles_and_Methods/principles_methods.asp. Accessed 2009 June 23.
- ADAMS KR. Plant materials in mortar samples from the West Ruin at Aztec Ruins National Monument, and from flotation samples at LA 1674, a Mesa Verde room block [manuscript on file]. Aztec (NM): Aztec Ruins National Monument; 2004c.
- ADAMS KR. Native (wild) plants from Salmon Pueblo. In: REED PF, editor. Thirty-Five years of archaeological research at Salmon Ruins, New Mexico. Volume Three: Archaeobotanical research and other analytical studies. Tucson (AZ) and Bloomfield (NM): Center for Desert Archaeology, and Salmon Ruins Museum; 2006. 741–757.
- ADAMS KR. Subsistence and plant use during the Chacoan and secondary occupations at Salmon Ruin. In: REED PF, editor. Chaco’s northern prodigies: Salmon, Aztec, and the ascendancy of the middle San Juan Region after AD 1100. Salt Lake City: University of Utah Press; 2008. 65–85.
- ADAMS KR. Charred plant remains. In: NIELY RB, editor. The Duval Mine Road site: Rincon Phase subsistence and settlement in the Middle Santa Cruz, Sahuarita, Arizona. Logan Simpson Design Technical Reports in Prehistory 3. Tempe (AZ): Logan Simpson Design; forthcoming.
- ADAMS KR, ADAMS RK. How does our agave grow? Reproductive biology of a suspected ancient Arizona cultivar, *Agave murpheyi* Gibson. *Desert Plants* 1998; 14(2):11–20.
- ADAMS KR, BOWYER VE. Sustainable landscape: thirteenth-century food and fuel use in the Sand Canyon locality. In: VARIEN MD, WILSHUSEN RH, editors. Seeking the center place, archaeology and ancient communities in the Mesa Verde region. Salt Lake City: University of Utah Press; 2002. 123–142.
- ADAMS KR, FISH SK. Southwest plants. In: UBELAKER DH, editor. Handbook of North American Indians. Volume 3, Environment, Origins, and Population. Washington (DC): Smithsonian Institution; 2006. 292–312.
- ADAMS KR, MURRAY SS. Identification criteria for plant remains recovered from archaeological sites in the Central Mesa Verde Region: compendium A, wood charcoal; 2004a. Available at http://www.crowcanyon.org/ResearchReports/Archaeobotanical/Plant_Identification/plant_identification.asp. Accessed 2009 June 23.
- ADAMS KR, MURRAY SS. Identification criteria for plant remains recovered from archaeological sites in the Central Mesa Verde Region: compendium B, charred

- nonwood specimens; 2004b. Available at http://www.crowcanyon.org/ResearchReports/Archaeobotanical/Plant_Identification/plant_identification.asp. Accessed 2009 June 23.
- ADAMS KR, TOLL MS. Tobacco (*Nicotiana*) use and manipulation in the prehistoric and historic southwestern United States. In: WINTER JC, editor. Tobacco use by Native North Americans: sacred smoke and silent killer. Norman: University of Oklahoma Press; 2000. 143–170.
- ADAMS KR, STEWART JD, BALDWIN SJ. Pottery paint and other uses of Rocky Mountain beeweed (*Cleome serrulata* Pursh) in the Southwestern United States: ethnographic data, archaeological record, and elemental composition. *Kiva* 2002a; 67(4):339–362.
- ADAMS KR, SMITH SJ, PALACIOS-FEST M. Pollen and micro-invertebrates from modern earthen canals and other fluvial environments along the Middle Gila River, central Arizona. Gila River Indian Community Anthropological Research Paper 1. Tucson: University of Arizona Press; 2002b.
- ADAMS KR, VAN WEST CR. Subsistence through time in West-Central New Mexico and East Central Arizona. In: HUBER EK, VAN WEST CR, compiled and edited. Archaeological data recovery in the New Mexico transportation corridor and first five-year permit area, Fence Lake Coal Mine project, Catron County, New Mexico. Volume 4: Synthetic studies and summary. Technical Series 84. Tucson (AZ): Statistical Research; 2005. 37.1–37.52.
- ADAMS KR, MEEGAN CM, ORTMAN SG, EMERSON HOWELL R, WERTH LC, MUENCHRATH DA, O'NEILL MK, GARDNER CAC. MAÍS (Maize of American Indigenous Societies) Southwest: ear descriptions and traits that distinguish 27 morphologically distinct groups of 123 historic USDA Maize (*Zea mays* L. ssp. *mays*) accessions and data relevant to archaeological subsistence models; 2006. Available at <http://farmingtonsc.nmsu.edu>. Accessed 2009 June 23.
- ADAMS KR, MURRAY SS, BELLORADO B. 2008. Chapter 8. Animas–La Plata supportive research projects. In: POTTER JM, editor. Animas–La Plata project: environmental studies. SWCA Anthropological Research Paper 10, Volume X. Phoenix (AZ): SWCA Environmental Consultants; 2008. 145–169.
- ANDERSON MK. Tending the wild: Native American knowledge and the management of California's natural resources. Davis (CA): University of California Press; 2005.
- ANONYMOUS. They found Awanyu's gifts. *The Atom* 1964; 1(11):19–21. Los Alamos (NM): Los Alamos Scientific Laboratory.
- BALA BK. Drying and storage of cereal grains. Enfield (NH): Science Publishers; 1997.
- BARTLETT K. Edible wild plants of Northern Arizona. In: Plants of Northern Arizona. Museum of Northern Arizona Reprint Series 1. Flagstaff: Northern Arizona Society of Science and Art; 1951. 46–52.
- BAYMAN F, PALACIOS-FEST M, HUCKELL LW. Botanical signatures of water storage duration in a Hohokam reservoir. *Am Antiq* 1997; 62(10):103–111.
- BEDWELL SF, CRESSMAN LS. Fort Rock report: prehistory and environment of the Pluvial Fort Rock Lake area of South-Central Oregon. In: AIKENS CM, editor. *Great Basin Anthropological Conference 1970: selected papers*. Anthropological papers 1. Eugene: University of Oregon; 1971. 1–25.
- BELL WH, CASTETTER EF. Ethnobiological studies in the American Southwest, VII: the utilization of yucca, sotol, and beargrass by the Aborigines in the American Southwest. *University of New Mexico Bulletin* 372, Biological Series 5(5). Albuquerque: University of New Mexico Press; 1941.
- BERGLUND BE, editor. *Handbook of Holocene palaeoecology and palaeohydrology*. Chichester (UK): John Wiley and Sons; 1986.
- BILLMAN BR, LAMBERT PM, LEONARD BL. Cannibalism, warfare, and drought in the Mesa Verde region during the twelfth century AD. *Am Antiq* 2000; 65(1):145–178.
- BIRKS HJB, GORDON AD. Numerical methods in Quaternary pollen analysis. Orlando (FL): Academic Press; 1985.
- BLACKBURN TC, ANDERSON MK, editors. Before the wilderness: environmental management by Native Californians. Ballena Press Anthropological Papers 40. Menlo Park (CA): Ballena Press; 1993.
- BOHRER VL. Ethnobotanical aspects of Snaketown, a Hohokam village in southern Arizona. *Am Antiq* 1970; 35(4):413–430.
- BOHRER VL. Paleoeecology of the Hay Hollow Site, Arizona. *Fieldiana Anthropol* 1972; 3(1):1–30.
- BOHRER VL. Plants that have become locally extinct in the Southwest. *New Mexico J Sci* 1978; 18(2):10–18.
- BOHRER VL. Methods of recognizing cultural activity from pollen in archaeological sites. *Kiva* 1981; 46(3):135–142.
- BOHRER VL. Guideposts in ethnobotany. *J Ethnobiol* 1986a; 6(1):27–43.
- BOHRER VL. The ethnobotanical record at Arroyo Hondo Pueblo. In: WETTERSTROM W, editor. Food, diet, and population at prehistoric Arroyo Hondo Pueblo, New Mexico. Santa Fe (NM): School of American Research Press; 1986b.
- BOHRER VL. Recently recognized cultivated and encouraged plants among the Hohokam. *Kiva* 1991; 56(3):227–236.
- BOHRER VL. Ceremonial and medicinal plants from Salmon Pueblo. In: REED PF, editor. Thirty-five years of archaeological research at Salmon Ruins, New Mexico. Volume Three: Archaeobotanical research and other analytical studies. Tucson (AZ) and Bloomfield (NM): Center for Desert Archaeology, and Salmon Ruins Museum; 2006. 859–866.
- BOHRER VL. Preceramic subsistence in two rock shelters in Fresno Canyon, South Central New Mexico. *Arizona State Museum Archaeological Series* 199. Tucson: University of Arizona; 2007.
- BOHRER VL, ADAMS KR. Ethnobotanical techniques and approaches at Salmon Ruin, New Mexico. *Contrib Anthropol* 1977; 8(1).
- BOHRER VL, ADAMS KR. Other botanical remains and special contexts. In: REED PF, editor. Thirty-five years of

- archaeological research at Salmon Ruins, New Mexico. Volume Three: Archaeobotanical research and other analytical studies. Tucson (AZ) and Bloomfield (NM): Center for Desert Archaeology, and Salmon Ruins Museum; 2006. 771–784.
- BOHRER VL, DOEBLEY JF. Cultivated plants from Salmon Pueblo. In: REED PF, editor. Thirty-five years of archaeological research at Salmon Ruins, New Mexico. Volume Three: Archaeobotanical research and other analytical studies. Tucson (AZ) and Bloomfield (NM): Center for Desert Archaeology, and Salmon Ruins Museum; 2006. 721–739.
- BOYD RT, editor. Indians, fire and the land in the Pacific Northwest. Corvallis: Oregon State University Press; 1999.
- BRYANT VM JR. Prehistoric diet in southwest Texas: the coprolite evidence. *Am Antiq* 1974; 39(3):407–420.
- BRYANT VM JR, DEAN GW. Archaeological coprolite science: the legacy of Eric O. Callen (1912–1970). *Palaeogeogr Palaeoclim Palaeoecol* 2006; 237(1):51–66.
- BRYANT VM JR, HALL SA. Archaeological palynology in the United States: a critique. *Am Antiq* 1993; 58:277–286.
- CASTETTER EF. Ethnobiological studies in the American Southwest I, uncultivated native plants used as sources of food. *Univ New Mexico Bull Whole Nr* 266. *Biol Ser* 1935; 4(1).
- CASTETTER EF, BELL WH, GROVE AR. The early utilization and the distribution of Agave in the American Southwest. *Univ New Mexico Bull Biol Ser* 1938; 5(4):1–92.
- CASTETTER EF, BELL WH. *Pima and Papago Indian agriculture Inter-Americana Studies. Volume I.* Albuquerque: University of New Mexico Press; 1942.
- CASTETTER EF, BELL WH. *Yuman Indian agriculture: primitive subsistence on the Lower Colorado and Gila Rivers.* Albuquerque: University of New Mexico Press; 1951.
- CROWN PL, HURST WJ. Evidence of cacao use in the Prehispanic American Southwest. *Proc Natl Acad Sci* 2009; 106(7):211–2113.
- CULLY A. Some aspects of pollen analysis in relation to archaeology. *Kiva* 1979; 44(2–3):95–100.
- DEAN G. Comment: use of pollen concentrations in coprolite analysis: an archaeobotanical viewpoint with a comment to Reinhard et al. (1991). *J Ethnobiol* 1993; 13(1):102–114.
- DEAN G. Finding a needle in a palynological haystack: a comparison of methods. In: BRYANT VM JR., WRENN JH, editors. *New developments in palynomorph sampling, extraction, and analysis.* Contribution Series 33. Dallas (TX): American Association of Stratigraphic Palynologists; 1998. 53–59.
- DEUR D, TURNER NJ, editors. *Keeping it living: traditions of plant use and cultivation on the northwest coast of North America.* Seattle and Vancouver: University of Washington Press, and University of British Columbia Press; 2005.
- DIMBLEBY GW. *The palynology of archaeological sites.* Orlando (FL): Academic Press; 1985.
- DOEBLEY JF. A preliminary study of wild plant remains recovered by flotation at Salmon Ruin, New Mexico [MA thesis]. Portales: Eastern New Mexico University; 1976.
- DOEBLEY JF. “Seeds” of wild grasses: a major food of Southwestern Indians. *Econ Bot* 1984; 38(1):52–64.
- DOEBLEY JF. Plant remains from trash deposits at Salmon Pueblo. In: REED PF, editor. Thirty-five years of archaeological research at Salmon Ruins, New Mexico. Volume Three: Archaeobotanical research and other analytical studies. Tucson (AZ) and Bloomfield (NM): Center for Desert Archaeology, and Salmon Ruins Museum; 2006. 759–770.
- DOEBLEY JF, BOHRER VL. Maize variability and cultural selection at Salmon Ruin, New Mexico. *Kiva* 1983; 49(1–2):19–37.
- DONGOSKE KE, MARTIN DL, FERGUSON TJ. Critique of the claim of cannibalism at Cowboy Wash. *Am Antiq* 2000; 65(1):179–190.
- DOOLITTLE WF. *Cultivated landscapes of native North America.* Oxford Geographical and Environmental Studies. New York: Oxford University Press; 2000.
- FEGRI K, IVERSEN J, KALAND PE, KRZYWINSKI K. *Textbook of pollen analysis.* 4th ed. Chichester (UK): John Wiley & Sons. 1989.
- FISH SK. Agriculture and subsistence implications of the Salt–Gila Aqueduct Project pollen analysis. In: TEAGUE LS, CROWN PL, editors. *Hohokam archaeology along the Salt–Gila Aqueduct Central Arizona Project. Chapter 1. Part III. Volume 7, Environment and subsistence.* Arizona State Museum Archaeological Series 150. Tucson: University of Arizona; 1984. 111–138.
- FISH SK. Archaeological palynology of gardens and fields. Chapter 3. In: MILLER NF, GLEASON KL, editors. *The archaeology of garden and field.* Philadelphia: University of Pennsylvania Press; 1994. 44–69.
- FISH SK. Corn, crops, and cultivation in the North American Southwest. In: MINNIS PE, editor. *People and plants in ancient western North America.* Washington (DC): Smithsonian Books; 2004.
- GEIB PR, JOLIE EA. The role of basketry in Early Holocene small seed exploitation: implications of a ca. 9,000 year-old basket from Cowboy Cave, Utah. *Am Antiq* 2008; 73(1):83–102.
- GEIB PR, SMITH SJ. Pollen washes and archaeological inference: bridging the gap between pollen washes and past behavior. *J Archaeol Sci* 2008; 35:2085–2101.
- GILBERT MTP, JENKINS DL, GÖTHERSTROM A, NAVERAN N, SANCHEZ JJ, HOFREITER M, THOMSEN PF, et al. DNA from Pre-Clovis human coprolites in Oregon, North America. *Science* 2008; 320:786–789.
- GISH JW. Current perceptions, recent discoveries, and future directions in Hohokam palynology. *Kiva* 1991; 56(3):227–235.
- GISH JW. Shelltown and the Hind Site: a pollen study of two settlements, with an overview of Hohokam subsistence. In: MARMADUKE WS, MARTYNEC RJ, editors. *Shelltown and the Hind Site, a study of two Hohokam craftsman communities in Southwestern Arizona. Volume 1.* Flagstaff, AZ: Northland Research; 1993a. 449–562.
- GISH JW. Special studies: privy pollen from the Gold Road Mine Town Site, Arizona. Chapter 12. In: WINTER JC,

- editor. Across the Colorado Plateau: anthropological studies for the Transwestern Pipeline Expansion project. Volume XV, Subsistence and Environment. Parts 1–3. Office of Contract Archaeology and the Maxwell Museum. Albuquerque: University of New Mexico; 1993b. 225–230.
- HALL S. Progressive deterioration of pollen grains in South-Central US Rockshelters. *J Palynol* 1991; 26:159–164.
- HAMMETT JE, LAWLOR EJ. Paleoethnobotany in California. In: MINNIS PE, editor. People and plants in ancient western North America. Washington (DC): Smithsonian Books; 2004. 278–365.
- HAVARD V. Food plants of North American Indians. *Bull Torrey Bot Club* 1895; 22:98–123.
- HAVARD V. Drink plants of the North American Indians. *Bull Torrey Bot Club* 1896; 23:33–46.
- HEVLY RH. Pollen production, transport, and preservation: potentials and limitations in archaeological palynology. *J Ethnobiol* 1981; 1(1):39–54.
- HODGSON W. Food plants of the Sonoran Desert. Tucson: University of Arizona Press; 2001.
- HOUSELY LK. *Opuntia imbricata* distribution on old Jemez Indian habitation sites [MA thesis]. Claremont (CA): Pomona College; 1974.
- HOVEZAK M, GEIB PR. Wood and fiber artifacts. In: GEIB PR, KELLER D, editors. Bighorn Cave: test excavation of a stratified dry shelter, Mohave County, Arizona. Bilby Research Center Occasional Paper 1. Flagstaff: Northern Arizona University; 2002. 106–133.
- HUBER EK, VAN WEST CR. Archaeological data recovery in the New Mexico Transportation Corridor and First Five-Year Permit Area, Fence Lake Coal Mine Project, Catron County, New Mexico. Volume 4, Synthetic studies and summary. Technical Series 84. Tucson (AZ): Statistical Research; 2005.
- HUCKELL LW. Plant remains from the Pinaleno Cotton Cache. *Kiva* 1993; 59:147–204.
- HUCKELL LW, VANPOOL CS. Toloatzin and shamanic journeys: exploring the ritual role of sacred datura in the prehistoric Southwest. In: VANPOOL CS, VANPOOL TL, PHILLIPS DA SR, editors. Religion in the prehistoric Southwest. Lanham (MD): Altamira Press; 2006. 147–163.
- HUISINGA KD. Cultural and biological factors that contribute to the distribution of *Salvia dorrii* Subspecies *mearnsii* [MA thesis]. Flagstaff: Northern Arizona University; 1999.
- KOHLER TA, MATTHEWS MH. Long-term Anasazi land use and forest reduction: a case study from Southwest Colorado. *Am Antiq* 1988; 53(3):537–564.
- LENTZ DL. The distribution patterns and fruit productivity of modern *Juniperus* growing in the Salmon Ruin Area and the archaeological interpretation of juniper seeds and cones found in Salmon Ruin, New Mexico [MA thesis]. Portales: Eastern New Mexico University; 1979.
- MABRY J. Diversity in early Southwestern farming and optimization models of transitions to agriculture. In: DIEHL MW, editor. Subsistence and resource use strategies of early agricultural communities in Southern Arizona. Anthropological Paper 34. Tucson (AZ): Center for Desert Archaeology; 2005. 113–152.
- MANN CC. 1491: New revelations of the Americas before Columbus. New York: Knopf; 2005.
- MANN D, EDWARDS J, CHASE J, BECK W, REANIER R, MASS M, FINNEY B, LORET J. Drought, vegetation change, and human history on Rapa Nui (Isla de Pascua, Easter Island). *Quatern Res* 2008; 69:16–28.
- MARTIN PS, SHARROCK FW. Pollen analysis of prehistoric human feces: a new approach to ethnobotany. *Am Antiq* 1964; 30:168–180.
- MCGREGOR JC. Burial of an early American magician. *Proc Am Philosoph Soc* 1943; 86(2):270–298.
- MERRILL WL, HARD RJ, MABRY JB, FRITZ GJ, ADAMS KR, RONEY JR, MACWILLIAMS AC. The diffusion of maize to the southwestern United States and its impact. *Proc Natl Acad Sci* 2009; 106(50):21019–21026.
- MINNIS PE. Prehistoric diet in the northern Southwest: macro-plant remains from Four Corners feces. *Am Antiq* 1989; 54(3):543–563.
- MOERMAN DE. Native American ethnobotany. A database of foods, drugs, dyes and fibers of Native American peoples derived from plants. Dearborn: University of Michigan; 2003. Available at <http://herb.umd.umich.edu>. Accessed 2010 Jan 5.
- MOORE PD, WEBB JA, COLLINSON ME. Pollen analysis. 2nd ed. Oxford: Blackwell Scientific Publications; 1991.
- MURRAY SS, ADAMS KR, SMITH SJ. Archaeobotanical methods. Chapter 9. In: POTTER JM, editor. Animas–La Plata project: environmental studies. SWCA Anthropological Research Paper 10. Volume X. Phoenix (AZ): SWCA Environmental Consultants; 2008. 171–192.
- NABHAN GP, WHITING A, DOBYNS H, HEVLY R, EULER R. Devil's claw domestication: evidence from Southwestern Indian Fields. *J Ethnobiol* 1981; 1(1):135–164.
- NASH MJ. Crop conservation and storage in cool temperate climates. 2nd edition. New York: Pergamon Press; 1985.
- O'ROURKE MK. Pollen from adobe bricks. *J Ethnobiol* 1983; 3(1):39–48.
- PALMER E. Food products of the North American Indians. Report of the Commissioner of Agriculture for 1870. Washington (DC) (reprinted by Caber Press); 1870.
- PALMER E. Plants used by the Indians of the United States. *Amer Nat* 1878; 12:593–606; 646–655.
- PEARSALL DM. Paleoethnobotany. A handbook of procedures. 2nd ed. San Diego (CA): Academic Press; 2000.
- RAINEY KD, ADAMS KR. Plant use by native peoples of the American Southwest: ethnographic documentation; 2004. Available at <http://www.crowcanyon.org/plantuses>. Accessed 2009 June 23.
- REA A. At the desert's green edge: an ethnobotany of the Gila River Pima. Tucson: University of Arizona Press; 1997.
- REINHARD KJ. The utility of pollen concentration in coprolite analysis: expanding on Dean's comments. *J Ethnobiol* 1993; 13(1):114–128.
- REINHARD KJ, BRYANT VM JR. Coprolite analysis: a biological perspective on archaeology. In: SCHIFFER MB, editor.

- Archaeological method and theory. Volume 4. Tucson: University of Arizona Press; 1992. 245–288.
- REINHARD KJ, BRYANT VM JR. Pathoecology and the future of coprolite studies in bioarchaeology. School of Natural Resources, Papers in Natural Resources. Lincoln: University of Nebraska; 2008. Available at <http://digitalcommons.unl.edu/natrespapers/43>. Accessed 2009 June 23.
- REINHARD KJ, MROZOWSKI SA, ORLOSKI KA. Privies, pollen, parasites, and seeds: a biological nexus in historic archaeology. *Mus Appl Sci Cent Archaeol J* 1986; 4:31–36.
- REINHARD KJ, GEIB PR, CALLAHAN MM, HEVLY RH. Discovery of colon contents in a skeletonized burial: soil sampling for dietary remains. *J Archaeol Sci* 1992; 19:697–705.
- RÖSCH M. Pollen analysis of the contents of excavated vessels—direct archaeobotanical evidence of beverages. *Veg Hist Archaeobot* 2005; 14:179–188.
- RUDDIMAN WF. Plows, plagues, and petroleum: how humans took control of climate. Princeton (NJ): University of Princeton Press; 2005.
- RULL V, CAÑELLAS-BOLTÀ N, SÁEZ A, GIRALT S, PLA S, MARGALEF O. Paleocology of Easter Island: evidence and uncertainties. *Earth-Sci Rev* 2010; 99:50–60.
- SHIPEK F. An example of intensive plant husbandry: the Kumeyaay of Southern California. In: HARRIS DR, HILLMAN GC, editors. *Foraging and farming: the evolution of plant exploitation*. London: Unwin Hyman; 1989. 159–167.
- SMITH BD. Low level food production and the Northwest Coast. In: DEUR D, TURNER NJ, editors. *Keeping it living: traditions of plant use and cultivation on the northwest coast of North America*. Seattle and Vancouver: University of Washington Press, and University of British Columbia Press; 2005. 37–66.
- SMITH SJ. Pollen analysis of mortar samples at West Ruin, Aztec Ruins National Monument [manuscript on file]. Aztec (NM): Aztec Ruins National Monument; 2004.
- SMITH SJ. Pollen analysis of Chinatown privies, San Bernardino California. Appendix D.2. In: COSTELLO JG, HALLARAN KK, WARREN K, editors. *The luck of Third Street historical archaeology data recovery report for the Caltrans District 8 San Bernardino Headquarters Demolition Project*. San Bernadina (CA): Department of Transportation EA 08-482900; 2005.
- SMITH SJ. LA 4618 pollen results. In: SCHMIDT KM, prep. *Excavations at a Coalition Period Pueblo (LA 4618) on Mesita del Buey*. LA-UR-06-6621. Los Alamos (NM): Los Alamos National Laboratory; 2006. 207–229.
- SMITH SJ. Pollen's eye view of archaeology on the Pajarito Plateau. In: VIERRA B, SCHMIDT K, editors. *The Land Conveyance and Transfer Data Recovery project: 7000 years of land use on the Pajarito Plateau*. Volume 3 Analyses. LA-UR-07-6205. Los Alamos (NM): Los Alamos National Laboratory; 2007. 523–595.
- SMITH SJ. Pollen analysis of agricultural terraces on La Plata Mesa, Agua Fria National Monument, Yavapai County, Arizona [unpublished ms; submitted to Sharon Hall]. Tempe: Arizona State University. 2009.
- SOBOLIK K. The prehistoric diet and subsistence of the Lower Pecos Region, as reflected in coprolites from Baker Cave, Val Verde County, Texas [MA thesis]. College Station: Texas A and M University; 1988.
- SOBOLIK KD, GERICK DJ. Prehistoric medicinal plant usage: a case study from coprolites. *J Ethnobiol* 1992; 12(2):203–211.
- STANDLEY PC. Some useful native plants of New Mexico. *Smithsonian Institute Annual Report of 1911*. Washington (DC): Smithsonian Institution; 1912. 447–462.
- STEVENSON MC. *Ethnobotany of the Zuni Indians*. Thirtieth Annual Report of the Bureau of American Ethnology. Washington (DC): US Government Printing Office; 1915.
- STIGER MA. *Anasazi diet: the coprolite evidence* [MA thesis]. Boulder: University of Colorado; 1977.
- STIGER MA. Mesa Verde subsistence patterns from Basketmaker to Pueblo III. *Kiva* 1979; 44(2–3):133–144.
- SUTTON MQ, REINHARD KJ. Cluster analysis of the coprolites from Antelope House: implications for Anasazi diet and cuisine. *J Archaeol Sci* 1995; 22:741–750.
- THOMPSON L. *To the American Indian: reminiscences of a Yurok woman*. Berkeley (CA): Heyday Books; 1991 [1916].
- TOLL MS, McBRIDE PJ. Botanical contents of two 17th c. baskets from a dry shelter in the Galisteo Basin, NM. *Museum of New Mexico Project* 41.573. Office of Archaeological Studies Technical Series 42. Albuquerque: Museum of New Mexico; 1996.
- VAN WEST CR. Modeling prehistoric climatic variability and agricultural production in Southwestern Colorado: a GIS approach [PhD dissertation]. Pullman: Washington State University; 1990.
- VAN WEST CR, DEAN JS. Environmental characteristics of the AD 900–1300 period in the Central Mesa Verde region. *Kiva* 2000; 66:19–44.
- VIERRA BJ, SCHMIDT KM, editors. *The Land Conveyance and Transfer Data Recovery Project: 7000 years of land use on the Pajarito Plateau*. Volume 4: Research Design. LA-UR-07-6205. Los Alamos (NM): Los Alamos National Laboratory, Los Alamos; 2008.
- VIVIAN RG, DODGEN DN, HARTMAN GH. Wooden ritual artifacts from Chaco Canyon New Mexico: the Chetro Ketl collection. *Anthropological papers of the University of Arizona*, nr 32. Tucson: University of Arizona Press; 1978.
- WAGNER GE. Comparability among recovery techniques. In: HASTORF CA, POPPER VS, editors. *Current paleoethnobotany: analytical methods and cultural interpretations of archaeological plant remains*. Chicago (IL): University of Chicago Press; 1988. 17–35.
- WATSON PJ. In pursuit of prehistoric subsistence: a comparative account of some contemporary flotation techniques. *Midcont J Archaeol* 1976; 1(1):77–100.

- WATT ET, with BASSO KH. Don't let the sun step over you: a White Mountain Apache family life, 1860–1975. Tucson: University of Arizona Press; 2004.
- WHITING AF. Ethnobotany of the Hopi. Bulletin 15. Flagstaff: Museum of Northern Arizona; 1939.
- WILLIAMS-DEAN G. Ethnobotany and cultural ecology of prehistoric man in Southwest Texas [PhD dissertation]. College Station: Texas A and M University; 1978.
- WILLIAMS-DEAN G. Pollen analysis of human coprolites. In: MORRIS DP, editor. Archaeological investigations at Antelope House. Publications in Archaeology 19. Washington (DC): National Park Service; 1986. 189–205.
- WILSON GL. Buffalo Bird Woman's garden: the classic account of Hidatsa American Indian gardening techniques. St. Paul: Minnesota Historical Society Press; 1987 [1917].
- WINTER JC, editor. Tobacco use by Native North Americans: sacred smoke and silent killer. Norman: University of Oklahoma Press; 2000.
- WOOSLEY AI. Pollen extraction for arid-land sediments. *J Field Archaeol* 1978; 5(3):349–355.
- YANOVSKY E. Food plants of the North American Indians. Miscellaneous Publication 237. Washington (DC): US Department of Agriculture; 1936.

Chapter 11

Reconstructing Past Life-Ways with Plants II: Human–Environment and Human–Human Interactions

DEBORAH M. PEARSALL

University of Missouri, Columbia, MO

CHRISTINE A. HASTORF

University of California, Berkeley, CA

INTRODUCTION	173
METHODS	174
MACROREMAINS	174
POLLEN	175
PHYTOLITHS	176
STARCH	176
HUMAN–ENVIRONMENT INTERACTIONS	177
HUMAN–HUMAN INTERRELATIONSHIPS	180
POLITICAL–SPIRITUAL–SOCIAL EVIDENCE FROM PLANTS	180
IDENTITY	181
DISCUSSION	183
REFERENCES	184

INTRODUCTION

As demonstrated in the Adams and Smith chapter, paleoethnobotany, the study of human–plant interrelationships through the archaeological record, provides direct evidence on how past populations met subsistence and other daily needs. In this chapter, we look at how paleoethnobotany contributes to understanding human interactions with their environments,

Ethnobiology. Edited by E. N. Anderson, D. Pearsall, E. Hunn, and N. Turner
© 2011 Wiley-Blackwell. Published 2011 by John Wiley & Sons, Inc.

and with each other. While we will provide separate discussions of these topics, the connections between the environmental and social worlds of past human societies were many and complex.

Humans interacted with their environments in a variety of ways that left traces in the archaeological and geological records. Wild foods were managed by fire (Abrams and Nowacki 2008) as well as fields cleared for cultivation (Zong et al. 2007). Landscapes were altered to increase or enable crop production by the creation of terraces (Horrocks and Rechtman 2009) and raised fields (Erickson 2006). Trees were planted to mark, use, and alter local microenvironments but also due to specific values (Gasser and Kwiatkowski 1991; Goldstein 2007; Johannessen and Hastorf 1996). Humans crafted landscapes, paths, settlements, water catchment features, irrigation works, and extracted fuels (Miller 1989). Plants were domesticated, transported across the landscape, and transformed from foreign foods into core staples. Both maize across South America and wheat, barley, and lentils into Europe illustrate the range of selective interests in foods and their processing that encouraged some and depleted other plants (Dietler 2007; Oeggl 2009; Piperno and Pearsall 1998). Farming had a profound impact on weeds, ruderal and segetal, and camp followers, with wild seeds indirectly indicating crop production and intensification (Jones 1984, 1987; Jones and Halstead 1995; van der Veen 2008). Cultural identities were created by land use (Hastorf 1994; Hastorf and Johannessen 1993); drink (Dietler 1990); food (Franklin 2001; Gifford-Gonzalez and Ueno Sunseri 2007; Jones, 2007; Twiss 2007); and feasts and politics (Dietler 1996, Dietler and Hayden 2001; LeCount 2001; Lev-Tov and McGeough 2007). Many studies now demonstrate the rich window that plants provide us into the past lives of people.

METHODS

Macroremains

For more details on the recovery and study of charred, waterlogged, mineralized, or dried remains of seeds, fruits, nuts, and roots/tubers, and their applications to understanding subsistence and other daily needs, see Adams and Smith (2011). Here we focus on the potential of macroremains when applied to cultural and environmental issues.

Macroremains provide information on environments in which past populations lived, since they are a subset of what was available locally to be gathered, accidentally introduced, or grown. But plant remains recovered from sites also represent cultural selections. Culturally selected species are not a cross-section of all available species, and so are particularly appropriate for providing insights into what plants were useful and valued than for environmental reconstruction *per se*. Adriano-Morán and McClung de Tapia (2008), for example, used charred wood from excavations in the Teotihuacan Valley, Mexico, to evaluate whether changes occurred in the intensity of use of different species through time. Continuity was revealed, suggesting forest management. Charred wood may also provide a high resolution record of woodland vegetation contemporaneous with site occupation, as demonstrated by Asouti (2003), who argued from the charcoal record of a Neolithic site in south-central Anatolia that terebinth/almond woodland steppe was present by the early Holocene.

Wollstonecroft et al. (2008) provide an example of new levels of analysis to get at past behavior. Experimenting with a commonly gathered Paleolithic plant, these processing experiments support how pounding, boiling, and baking were all applied to enhance and expand diet. Building on Wandsnider (1997) and Stahl (1989), this project emphasized tuberous, subterranean storage tissues and their likely participation in diet. From

experimentation and images we learn much about “invisible” food plants, which survive surprisingly well. Weiss et al. (2008) illustrated the power of macroremains in reconstructing activity areas in a sealed floor of an Upper Paleolithic hut at Ohalo II, Israel. Using continuous density plots of major taxa recovered on the floors, non-random plant distributions were recognized which, in conjunction with features and artifact distributions, suggested gender-related use of space, including processing foods and medicinal plants.

Pollen

Reconstructing past vegetation and climate and detecting human impacts on past environments are goals of stratigraphic palynology (Faegri et al. 1989; Moore et al. 1991; Pearsall 2000; for archaeological applications see Adams and Smith, 2011). Permanently waterlogged sediments (swamps, lake bottoms, ocean floors) in which biological decomposition of pollen is inhibited are preferred sampling locations. Plants that are pollinated by wind contribute large quantities of pollen across the landscape, including water surfaces. Pollen sinks and becomes incorporated into bottom sediments, which over time accumulate and preserve a record of past vegetation. Not a perfect record: species are commonly over- or underrepresented depending on differential pollen production, dispersal, and destruction. Sampling contemporary pollen rain and studying pollen in surface soils from known vegetation types are two approaches used to determine pollen representation and to aid interpretation. Waterlogged sediments are sampled for pollen through coring: inserting a side-filling or bottom-filling tube into the sediments, closing the chamber, and extracting it intact. The corer is inserted multiple times into the same hole to retrieve a complete record. Once laid out in stratigraphic order and opened (by extruding the sediments or cutting open the tubes), core sediments are described and samples removed for dating (wood, highly organic sediments), chemistry, and chemical extraction of pollen (and phytoliths, see below). Microscopic charcoal and spores are also recovered and counted in pollen extracts and can tell us much about regional fire regimes.

Stratigraphic pollen data are presented in a pollen diagram, a standardized graph that depicts the proportion or absolute count of each type in each sampled stratum. The conventional order for listing identifications is arboreal taxa, shrubs, herbs, and spores, but taxa may be ordered by ecological groups or include categories such as disturbance or cultivated plants as an aid to interpretation. Because it is difficult to interpret a long stratigraphic record with many types, sequences are divided into smaller units, or pollen biozones, places in the sequence in which the analyst sees several concurrent changes in frequencies or absolute counts of types (e.g., a decrease in primary forest taxa and an increase in taxa favoring open habitats). Numerical approaches are often used to delineate pollen zones (Birks and Gordon 1985). Pollen and spore assemblages—the taxa present and their abundances—along with absolute pollen concentration and patterning in microscopic charcoal concentration are key to establishing pollen biozones and interpreting changes in terms of past regional vegetation and human impact.

Human interactions with their environments are often “captured” in stratigraphic pollen and phytolith records, which provide landscape-level views to complement archaeological site-level data. Piperno and Jones (2003), for example, identified significant burning around Lake Monte Oscuro in Pacific coastal Panama which, in association with increases of weedy plants, indicated that slash-and-burn cultivation was being practiced, while Atahan et al. (2008) identified localized environmental impacts (deforestation) of early agriculture in the lower Yangtze delta, China.

Phytoliths

Phytoliths, microscopic plant opal silica bodies, are produced in stems, leaves, roots, and inflorescences of plants. Silica that forms phytoliths is carried up from groundwater as monosilicic acid, and deposited in epidermal and other cells of growing plants. In many taxa, distinctively shaped bodies are formed which, after being released back into soils or sediments through plant decay or burning, can be recovered to provide insight into past vegetation or plant use (Madella and Zurro 2007; Pearsall 2000; Piperno 2006b). Decades of research have shown a strong genetic component to phytolith formation: families and orders of plants show strong tendencies to silicify or not silicify their tissues; production of many phytoliths is consistent within the same taxon under different environmental conditions. While silicification patterns are redundant in some groups, many taxa produce morphologically distinctive phytoliths that are diagnostic at the genus or species level, or even plant tissue (e.g., *Calathea* and *Maranta* root phytoliths; Chandler-Ezell et al. 2006). Size is sometimes used to separate phytoliths produced by closely related taxa (e.g., separating wild and domesticated rice glume cells; Zhao et al. 1998), or a plant may be identified by its phytolith assemblage (Hart and Matson 2009; Lu et al. 2009).

Phytoliths are inorganic and survive in contexts in which organic remains may not be well preserved, for example in sediments subject to repeated wetting and drying (macroremains only preserve if charred, and are subject to breakage; pollen and starch are subject to decay). Highly alkaline conditions (approaching 9 and above) may lead to phytolith dissolution. Once deposited by organic decay, burning, or in the course of digestion (i.e., in gut contents or coprolites), phytoliths move little in stable soils. In fact a challenge of phytolith processing is breaking the chemical bonds between phytoliths and soil constituents (Zhao and Pearsall 1998). Phytoliths move if the soil or sediment in which they are deposited moves; fluvial action deposits phytoliths in lakes or swamps (Piperno 1991, 1995), and phytoliths are transported in wind-blown dust (Fredlund and Tieszen 1994; Twiss et al. 1969). Pearsall (2000) and Piperno (2006b) discuss recovering phytoliths from sediments, soils, and artifacts.

Phytolith analysis contributes to our understanding of past human–plant interrelationships. Reconstructing past vegetation and detecting human impacts on past environments are investigated through stratigraphic phytolith analysis, which is similar in approach and objectives to stratigraphic palynology. Sampling cores for both pollen and phytoliths increases the numbers of taxa identified. Phytoliths recovered from archaeological contexts contribute in ways similar to macroremains, for example, in identifying food plants and determining their relative importance (through ubiquity) or distribution in a site (Pearsall et al. 2004). Plants that rarely come in contact with fire (e.g., medicinals, raw fruit, or plants used in floor mats and roof thatch) or produce macroremains that are fragile (e.g., roots and tubers) may be identified by phytoliths (Chandler-Ezell et al. 2006). Separating anthropogenic and natural phytolith “signals” can be challenging in site contexts; one approach is comparing assemblages from sites to natural deposits or macroremain assemblages (Pearsall 2004).

Starch

Ancient Starch Research, edited by Robin Torrence and Huw Barton (2006), provides an overview of the growing applications of starch analysis. Scholars were slow to realize that starch is common and well preserved on artifacts (Loy et al. 1992; Piperno and Holst 1998), including cooking vessels (Zarrillo et al. 2008) and grinders/pounders

(Chandler-Ezell et al. 2006; Pearsall et al. 2004), in sediments (Horrocks et al. 2004; Horrocks and Rechtman 2009), and in dental calculus (Henry and Piperno 2008; Piperno and Dillehay 2008). Foods with starchy subterranean storage organs (roots, rhizomes, corms, tubers) that have scant macroremains or are not phytolith producers may be identifiable by starch. Calculus and artifact studies provide evidence that past diets were often broader than have been envisioned from other indicators (Piperno 2009). While much starch research has focused on domesticated plants, many wild plants produce diagnostic starch and hold potential for identifying foods and medicines of hunter-gatherers (Zarrillo and Kooyman 2006).

Starch serves as a plant energy reserve (Bott et al. 2006). Some is transitory—formed during the daylight hours and converted back to sugar at night. Other starch is designed for long-term energy storage. Storage starch is what humans target for food. It tends to be concentrated in seeds and underground storage organs, but may also be found in stems, like palm pith, in tree sapwood, and in fruits such as plantains and chilies.

Starch forms in amyloplasts, beginning at a point called the hilum, and grows by successive layers (lamellae), which may remain visible on the granule (Bott et al. 2006). Starch is semicrystalline and exhibits strong birefringence, that is, under polarized light it appears white against the black background, and an extinction cross, a dark cross centered on the hilum, is visible (but may disappear in damaged or heated starch; Henry et al. 2009; Valamoti et al. 2008). Storage starch morphology is largely under genetic control, and many plants can be identified by their starch. Among the characteristics used for identification are granule shape and size, hilum location, extinction cross characteristics, fissure presence and shape, surface and edge characteristics, and whether granules are simple or compound (Bott et al. 2006). Starch granules are often characterized using a few distinctive traits, but it is sometimes necessary to apply multivariate analysis (Torrence et al. 2004). Starch swells in water, a change that is reversible at low temperatures. When heat is applied with water, a point is reached—gelatinization—at which irreversible changes in starch occur, eventually producing amorphous masses (Bott et al. 2006). Torrence (2006) and Fullagar (2006) discuss how to recover starch from sediments and artifacts.

HUMAN–ENVIRONMENT INTERACTIONS

One exciting area is the study of how people created productive agricultural lands that sustained populations for many generations, in some cases at densities as great as or greater than today's. An important aspect of this research is documenting ancient cultivation practices at a variety of scales. For example, Horrocks et al. (2004) studied sediments from stone mounds from a site in northern New Zealand. Starch of sweet potato was recovered, suggesting that one large mound was used for the cultivation of this introduced species. Microclimatic advantages included better heat retention and reduced frost damage to this warm climate species. Insights into Polynesian cultivation practices of an exotic plant were gained. Denham and Haberle (2008) combined multiple lines of evidence at different scales from the Upper Wahgi valley, Papua New Guinea, to develop a chronology of plant exploitation practices (wetland cultivation, dryland cultivation, patch disturbance, foraging) and an understanding of how different practices were overlaid in the landscape at different times. Key data included starch and phytoliths recovered from tools and cultivation surfaces, leading to identification of yam, taro, and bananas, and contributing to understanding local wetland manipulation and cultivation. Paleoenvironmental records revealed anthropogenic disturbance on a landscape scale. This New Guinea example demonstrates the multilayered

character of plant exploitation and early agriculture, rather than a binary opposition of agriculture and foraging. As argued in Denham and Barton (2006), agriculture emerged from pre-existing foraging strategies, and continuities in practices such as patch creation and plant translocation existed. Microfossil data facilitated these insights by opening up more contexts for data recovery.

Dryland farming systems in the Hawaiian Islands have been the subject of recent study by several researchers. Kirch et al. (2005) investigated a dryland farming area in the Kahikinui district, southeast Maui. The survey revealed that most pre-contact habitation, agricultural, and ritual sites were located in what would have been the most productive zone for sweet potato and dry taro. By combining archaeological, paleoethnobotanical, and geochemical data, they demonstrated that this landscape was farmed using a combination of practices. Agricultural features produced by digging stick cultivation (poking holes for planting) and also by soil turning/mounding (opening up the earth) were identified. Digging stick cultivation created conditions suitable for taro—mixed ash and cinder to create a productive loam soil and plant access to underlying water—while soil turning/mounding provided the better drainage needed by sweet potato. The fill within the features showed a significant loss of plant nutrients in comparison to soils outside. Wood charcoal absence indicated a lack of regular burning of woody taxa, as would have been expected under an *extensive* long-fallow system (i.e., allowing resting fields to return to forest); instead, an abundance of agricultural weed seeds and phytoliths produced by grasses and herbs indicated more *intensive* short-fallow (i.e., a shorter resting period, in which vegetation reverts to grasses, herbs, and shrubs). In combination, these lines of evidence showed intensive and repeated use of a particular substrate for dryland farming.

Horrocks and Rechtman (2009) conducted a microfossil study of features in the Kona Field system on the island of Hawai'i, a dryland cultivation area characterized by stone field walls, mounds, terraces, enclosures, and stone-lined trails. Features were sampled for pollen, starch, and phytoliths. Banana phytoliths were found in most samples, sweet potato starch and xylem in all features, but no other typical Polynesian cultivars. These results support a model of crop-specific resource zones, as identified in ethnohistorical records. Higher concentrations of starch and xylem in older samples suggested that cultivation was more intensive earlier in the sequence (Horrocks and Rechtman 2009).

As reviewed by Kirch (2007), coring in wetlands on O'ahu and Kaua'i, islands on which large tracts of irrigated pondfields exist, documented that human activities, including use of fire, had a significant effect on lowland vegetation soon after the islands were occupied (ca. AD 800). Pollen records showed how forest composition changed, with lowland forests largely replaced by managed agroecosystems by AD 1200. By contrast, higher regions retained forests into historic times, demonstrating that traditional cultivation practices were not focused on that zone. Archaeologically recovered charcoal also provided insights into vegetation change. Charcoal recovered from a rockshelter on Moloka'i Island documented the transformation of a diverse dryland forest into a landscape dominated by shrubs and herbs, representing short-fallow cultivation. The late prehistoric dryland and pondfield cultivation systems of the Hawaiian Islands represented intensive land management systems that were efficiently managed and potentially sustainable, if not equally benefiting all members of this incipient state (Kirch 2007).

Agricultural origins is one of those “big” questions that is revisited by each generation of researchers. A significant recent development is the expansion of the *kinds* of data that can be brought to bear; there are fewer methodological limitations on our ability to recover paleoenvironmental and archaeobotanical data needed to test hypotheses concerning the *how* and *why* of food production (Piperno 2006a). There is also increased emphasis on

thinking of the transition to agriculture as not only humans interacting with individual species, but interacting with suites of resources or whole landscapes. Examples from the American tropics illustrate these trends.

Piperno (2006a) and Kennett et al. (2006), among others, frame agricultural origins in terms of human behavioral ecology foraging theory: looking at suites of resources (fruits, seeds, underground storage organs of plants; animal species of different sizes and habits) in terms of caloric rates of return. Kennett et al. (2006) argue, for instance, that the establishment of maize-based food production on the Pacific coast of southern Mexico was a long, gradual process because cultivating maize provided a relatively low rate of return compared to other resources. Piperno (2006a) reasons broadly that dramatic declines in foraging return rates of glacial-period resources occurred in the early Holocene as forest expanded into formerly open habitats, leading to use of lower ranked resources, including ancestors of domesticated plants. Paleoenvironmental data provide a window into the timing and trajectory of these landscape-level transformations (Piperno and Pearsall 1998).

Erickson (2006) characterizes the profound prehistoric transformations of the low-lying Llanos de Mojos of the Bolivian Amazon (building of raised fields, causeways, reservoirs, forest islands, fish weirs, settlement mounds) as the creation of domesticated landscapes, managed environments that made marginal lands productive and increased biodiversity. Arguing from an historical ecology perspective, he proposes that Amazonian populations actively determined the nature of their environments, rather than adapted to existing conditions, and that agriculture was “simply a logical, intentional, historically contingent outcome of long-term intensive occupation, use, transformation, creation, and domestication of the Neotropics by humans” (Erickson 2006: 239). Studying such constructions across a region demonstrates how the results of landscape domestication/creation can be profound and long-lasting: the pre-Hispanic transformation of the Llanos de Mojos resulted in permanent alterations in topography, hydrology, and biodiversity, which continue to be present and to be, on occasion, operative today.

Anthropogenic forest disturbance is ancient in the Americas, as is using fire as a management tool (Piperno and Pearsall 1998). Research in the Maya region (southern Mesoamerica) illustrates the “entwined relationship” (Ford and Emery 2008: 150) of contemporary and ancient populations and the forest, a relationship that has endured for millennia through constant adaptation by the Maya to local and regional environmental and political circumstances. For example, the majority of the dominant plants of contemporary Maya forests, including native species, are important as foods, medicines, for construction, and other uses, suggesting long-standing forest management for useful species and garden escapes (Campbell et al. 2006; Ford 2008). Because the majority of these taxa are not wind pollinated, Ford (2008) purports that they are underrepresented in regional paleoenvironmental records, which show increasing proportions of pollen of open indicators (herbs, grasses) over time, interpreted as deforestation. Study of contemporary forest gardens suggests that elevated levels of herbs and grasses signal past human management of a mosaic of fields, regenerating fallows, and managed forests, which contributed to the resiliency of the forest by providing for species encouragement (Ford 2008).

As examples from the Pacific discussed earlier illustrate, understanding the nature of human interactions with the environment is facilitated by multiple lines of evidence at different scales of analysis. In the case of paleoenvironmental studies, incorporating pollen, phytolith, and particulate charcoal data gives a more nuanced view of vegetation than relying on single indicators. For example, palynologically underrepresented plants may be phytolith producers; patterning within the particulate charcoal signal may serve as a proxy for the intensity/frequency of burning. Further, regional-scale data provided by

environmental cores may provide the earliest glimmers of human impacts on/alternations of landscapes. Neff et al. (2006), for example, were able to examine the impact of archaeologically “invisible” Archaic period populations on the landscape of Pacific coastal Guatemala through a regional coring program. Evidence from three locations documented humans on the landscape earlier than the dates of known sites, in the Sipacate region at around 3500 cal BC. Maize, squash, *Maranta* (arrowroot genus), and other useful plants were identified in the context of low disturbance indicators and relatively low charcoal concentrations. Shortly after 3500 cal BC, arboreal indicators, especially pollen but also phytoliths, sharply declined and charcoal concentrations rose dramatically, and remained elevated but fluctuating until around 2600 cal BC, suggesting multiple episodes of anthropogenic burning. Trees did not disappear, however, and among the taxa present were economically useful plants and those favoring secondary growth.

We have only a coarse-grained perspective on cropping and other management practices that produced vegetation patterning such as that described for Pacific coastal Guatemala. Cultivation began before forest clearance, likely on naturally open lands such as river alluvium; fire was used to create and maintain more arable land from dry tropical forest; forests were resilient. To understand more would require the study of plant microfossil and particulate charcoal assemblages from forest, fallow, and field plots of known composition and management practices to develop analogues for interpreting ancient proxy data (Pearsall 2007).

HUMAN–HUMAN INTERRELATIONSHIPS

Political–Spiritual–Social Evidence from Plants

In arid regions fuel remains an issue, as foraging peoples can quickly denude trees and large shrubs of their dead wood. Cooking fuel becomes grass and small shrubs within weeks of residence, prompting people to move on before food sources are exhausted. A famous example is Chaco Canyon in the American Southwest, where spruce and fir wood from the mountains 75 miles away was brought in to build large ceremonial structures (Betancourt et al. 1986), and fuel was imported. Lentz and colleagues (2005) uncovered how pine wood was so valuable that its archaeobotanical distribution reflects the difference in access or price in the neighboring Maya communities of Xunantunich, San Lorenzo, and Chan Nòhol. Studying samples from a range of domestic areas on the Late and Terminal Classic settlements, the authors tracked the density and presence of pine wood. Pine grows in hillside forests some 17 km distance from the settlement, thus we know that this wood was transported into the community. There is good support for wood being converted to charcoal before use as cooking fuel. Pine also was used in house construction and in rituals, its resin producing incense. The authors ranked the households into commoners and elites, based on house-mound size, labor required for their construction, non-local ornaments, and tools, suggesting ties with ruling families. Identified wood shows that the largest settlement, Xunantunich, received the most pine in both primary (house construction) and secondary (rubbish mounds) contexts. Farmers in the smaller hamlets (Chan Nòhol) had the least amount of pine within their homes. Based on this patterned pine distribution within and between the settlement’s households, the authors conclude that pine wood was distributed in a selective, socially informed manner, perhaps as gifts between leaders and other residents. Even if that was not the case, different communities and families clearly had differing access to pine, which was shipped downriver into this region. For many symbolic reasons this commodity was selectively accessible.

While Lentz and colleagues did not discuss individual choice and decision-making explicitly, this conclusion was active in the non-random pine wood distribution. Such non-normal distribution is a red flag that sets paleoethnobotanists off on the search for non-ecological reasons for plant distributions. Such an approach was initiated by Tipping (1994) when he worked with pollen frequencies in Bronze Age Scottish graves. Tipping found a higher than expected presence of lime pollen (*Tilia*), which is common in honey and mead, in burial cists. Meadowsweet (*Filipendula*) was also unusually present, suggesting its addition as a flavoring to the drink or simply as a sweet-smelling bouquet (Tipping 1994: 137–138). Given that some concentrations were associated with ceramic vessels that appeared tipped over, Tipping suggests that ceremonial foods, drinks, and flowers were offered to the dead at the time of burial. While he does not take these plant-offering interpretations further, each of these plants will have had meaningful value for the inhabitants of southern Scotland.

An innovative study at Petzkes Cave, New South Wales, found that distributions of both starch and charcoal recovered from sediments were a good reflection of the spatial pattern of past use of a small living space (Balme and Beck 2002). By studying the densities of these remains, not the taxa themselves, they identify spatially discrete activity areas, where plants were stored, processed, and cooked, allowing us to begin to discuss the levels of fluidity or constriction of the occupants. Additionally, through this detailed analysis, we learn that these plant remains were more likely to remain *in situ* than the deposited stone artifacts, which were affected by trampling. Dense patches of sediment starch were interpreted as plant processing areas.

Identity

People eat what is local, what they can find through their own collecting or production, but also they eat what they desire, what tastes good. Traditional preferences begin in childhood with an inborn desire for sweet and salty, fatty and juicy, but for each group or family lived culinary traditions develop that reflect individual choices through generational practices being passed from one cook to another. These recipes, even if they are simply ways of cutting up a plant or the intensity of fire under a pot, speak to the values and opinions of the cooks and their consumers. In this way, cultural groups are maintained, not through discursive discussions about identity, but through daily practices of plant storage, processing, cooking, and eating. Thus paleoethnobotanists must augment their patchy data by studying the multiple patterns of plants, cooking vessels, grinding stones, as well as other foodstuffs, scattered around habitation areas. This is culinary archaeology.

In discussing the politics of cuisine, Dietler (2007) clarifies a concept that will help paleoethnobotanists as they trace and understand the uptake of plants in diets over time. He describes the indigenization of dishes, foods, and plants as they were traded out of their home territory. Clearly people can be curious about new things to eat, and that means new plants to grow, store, and prepare. But this was not blind acceptance. Adoptions were channeled through operative taste values and acceptable preparation methods in addition to the possibility of local production. As Fuller (2005), Hastorf (1999, 2006), and Lyons and D’Andrea (2003) have pointed out, plants and meals have selective and distinct uptake paths. The literature displays several of these cultural and technological histories. Sometimes a new food item is similar to those grown locally and used in local cuisine, making it easy to add or substitute within an ongoing tradition. Some foodstuffs are unique to the local cuisine and broaden it. Another successful introduction path

occurs when production and processing technologies within the group's arsenal allow the new crop to fit into the food cycle, whether it is less or more expensive to procure.

Another cultural concept that channels plant uptake is the associated sensory meanings that arrive with a new food item: flavor, texture, color, and taste. Associated symbolic meanings can accelerate consumption of certain foods, as people actively seek out ingredients, as well as develop successful propagation of these crops (Hastorf 1999). Some plants become core foods of a region, like grapes in France or rice in Japan, or remain occasional foods, like saffron in England. These various pathways, and the specifics of a plant's production, processing, and recipes help to illustrate how such dishes become part of traditional foods and core cuisines of specific communities. A powerful example of the rise of an indigenized plant is the tomato's place in Italian cuisine. Tomato is a Central/South American crop, brought to Europe in the 1500s. Then it was considered poison or worse, linked to the apple and the original sin in the Biblical Garden of Eden. Yet, by the 1900s everyone associated the red juicy tomato with Italian meals, the flavor and color becoming the core of "traditional" motherly Italian cooking (Allen 2002). The "Irish" potato had a very different history of acceptance onto that island yet it also became a core food for the laboring, rural masses, accomplished through landlords' pressure to force indentured farmers to convert from grain production to tuber production (Messer 1997). Yet by the time of the great famine in the 1840s, many thought the potato so thoroughly Irish, it was considered native to that island. These classic examples of the indigenization process of plants and dishes chart the cultural decisions and values of the community under study. This process illustrates how the foreign, exotic plant becomes so important in the new culinary setting that it becomes central in the traditional cuisine. Such invented traditions lurk in all societies, as people create cohesion while effecting change (Hobsbawm and Ranger 1992). However, these processes are not without their histories and can illuminate the specific values and meanings of the people.

These examples display the multiple actions of cultural choice and selection. An example of resistant adoption in cooking is seen in the movement of wheat and bread making into Africa from the Near East. Lyons and D'Andrea (2003) trace ingredient acceptance tempos in Ethiopia and link these to the foreign food processing technology. Different from the new planting regimes required for Irish farmers, these authors focus on the impediment of the processing differences between local, traditional griddle baking for teff versus oven bread making for wheat. As well we see the impact of gender on food practices, as bread making remained in the female domain. It was they who literally had to learn to build and operate ovens. This additional temporal hurdle in a busy day slowed the conversion to leavened bread baking in highland Ethiopia.

Consumption plays an important role in reaffirming cultural identity. Fuller (2005) discusses the agency of cultural identity in the divergent food uptake trajectories and indigenization of millet and mung beans across India. He traces the selective activities that accompanied the different plants as they spread across the continent via their processing and cooking activities and how these have adjusted with the crop introductions. Technology impacts the tempos of these plant immigrations and their reception in the local cuisines. The movement and cultural meanings of the plants are linked to how they were produced and cooked. Further, one can ask what recipes had to be altered or invented to incorporate these new foods and what were the cultural settings that allowed this to happen? Fuller links production with consumption. He suggests that ceramic production and its use in food processing circumscribes modes of adoption as well as the meanings that had accompanied this addition, tying crops to their recipes. Building four models of adoption of foreign foods based on linguistic types of adoption, Fuller provides material correlates in both the plants and the ceramics.

One plant movement model is operating in the African and northern Indian crop introduction southwards. In these situations, with no new ceramics associated with the processing, this trajectory reflects an easy adoption, where the introduced plants could be processed like extant plants. In a second model Fuller traces the introduction and acceptance of wheat and barley into the southern Deccan region of the Indian subcontinent during the Neolithic. These crops arrive as a complex, accompanied by new ceramic vessels, perhaps for the brewing of beer and a new processing technology. While these two regions are similar environmentally, Fuller suggests that their two populations adopted this suite of food crops differentially, displaying their active cultural decisions in the spread of food crops. Fuller's study explores local values and concerns through the adoption of non-local foods and plants that fit into the cultural and political world, not unconsciously or uniformly but uniquely; each plant was thoughtfully taken up into the agricultural cycle for its own merit, becoming reformed within the local world view as a "traditional" crop of value.

Studying tubers, Kubiak-Martens (1999, 2002) and Hardy (2007) focus on the mostly invisible starchy food staples of the northern European Mesolithic diet. By studying both tuber taxonomy and starch grains these scholars allow us to move beyond the large literature that emphasizes the Mesolithic focus on seafood and meat and realize that these foragers also ate many vegetables. Kubiak-Martens (1999, 2002) studied several submerged Ertebølle sites at which a range of foodstuffs has been found, suggesting they ate rhizomes from the local marsh and nuts from the nearby forests and meadows. They flavored their meals with onions, and ate grains, seeds, berries, fruit, nuts, and a range of underground storage roots-rhizomes like bull rush, club-rush, beets, and pignuts, all roasted in pit ovens, a strongly vegetable diet (Kubiak-Martens 1999). This evidence provides a more robust view of daily practices as well as a much broader diet than previously portrayed. Both authors gained traction from ethnoarchaeological work in North America and Australia respectively, allowing skeptics of starch analysis to see its value in food studies.

Other work that has given archaeologists new, more robust reinterpretations of past life-ways is the Amazonian research of Perry (2004, 2005), in which she demonstrated that objects oft labeled "manioc graters" actually were used for maize and other crop processing. Starch analysis allows us to refocus our imagination as well as our scientific knowledge—in this case of women's daily work in food preparation. Chandler-Ezell et al. (2006) also used starch analysis to learn about the diversity of utensil use in early domesticated processing. In a study of stone tools at the Real Alto site, they have found manioc (*Manihot esculenta*), arrowroot (*Maranta arundinacea*), llerén (*Calathea* sp.), and maize, in both unaltered, damaged, and gelatinized starch, informing us of potential recipes as well as the flexibility of tool use. Likewise, in the recent study of Middle Stone Age tools from Sibudu Cave in South Africa, Williamson (2004) has clear evidence of plant remains on tools previously assumed to have been used for animal hunting and butchering. Such studies are forcing the archaeological vision of the past to broaden and include more often the large role of plant food in the daily activities and diet of the past.

DISCUSSION

Paleoethnobotany is expanding not only the archaeological database, but also its potential to address a range of anthropological and environmental issues. Because we can now encounter plant evidence that was not obtainable earlier, through starch and phytoliths, residue analysis, and more detailed macroremain collection, we can address many more questions than was previously possible.

Studying how people created productive agricultural lands is one exciting area of research in which substantive advances are being made. But research such as that being carried out in New Guinea, Hawaii, and the lowland Neotropics also illustrates the complexity of identifying the processes by which people created and maintained agricultural systems.

All avenues are being followed: methods, analysis (Madella 2007), and interpretation, from in-depth detailed work, as at Çatal Höyük with micromorphological analysis in association with phytolith analysis (Matthews et al. 1997); or studying the full range of influences on Ötzi's life and region (Jacomet 2009). But more work still can be done on social aspects. Why did some neighbors eat more rhizomes while others focused on grains within the same time frame? These questions become answerable when we build on the biological, ecological, and economic data but seek out questions of taste, value, and historical choice. Cuisine plays a large role in creating social and individual identity today, and surely did so in the past.

Part of the power of paleoethnobotany comes from applying multiple datasets to the same general question. Oeggl (2009) provides the striking example of the Ice Man's life and activities. The rich texture of his life takes ever more shape through his plant use and movement across his taskscape (Ingold 1993). As with every material in the archaeological record, taphonomic concerns are important in the analysis; processing sequences and *chaines operatoires* loom large. More than just Schifferian taphonomic natural and cultural sequences, however, we need to focus on hard-won contextual identifications. Miksicek's (1987) discussion of the four major types of deposition helps us towards this fundamental starting point of our research between the trowel and the published interpretation. Each stage must be discursively discussed and revisited, like Wright's (2005) flotation article. Van der Veen (2007) revisits the issue of interpretation and deposition, suggesting that because we basically study daily practices, our data, however patchy, is more robust than usually assumed. Again, interpretation is further strengthened with multiple datasets. Therefore we close this brief discussion by reminding the reader of the wonderfully rich plant use that existed in the past where everything was carried in a basket, and most meals were plant based.

REFERENCES

- ABRAMS MD, NOWACKI GJ. Native Americans as active and passive promoters of mast and fruit trees in the eastern USA. *Holocene* 2008;18:1123–1137.
- ADRIANO-MORÁN CC, McCLUNG DE TAPIA E. Trees and shrubs: the use of wood in prehispanic Teotihuacan. *J Archaeol Sci* 2008;35:2927–2936.
- ALLEN SL. *In the Devil's garden: a sinful history of forbidden food*. New York: Ballantine; 2002.
- ASOUTI E. Woodland vegetation and fuel exploitation at the prehistoric campsite of Pinarbasi, south-central Anatolia, Turkey: the evidence from the wood charcoal macroremains. *J Archaeol Sci* 2003;30:1185–1201.
- ATAHAN P, ITZSTEIN-DAVEY F, TAYLOR D, DODSON J, QIN J, ZHENG H, BROOKS A. Holocene-aged sedimentary records of environmental changes and early agriculture in the lower Yangtze, China. *Quatern Sci Rev* 2008;27:556–570.
- BALME J, BECK WE. Starch and charcoal: useful measures of activity areas in archaeological rockshelters. *J Archaeol Sci* 2002;29:157–166.
- BETANCOURT JL, DEAN JS, HULL HM. Prehistoric long-distance transport of construction beams, Chaco Canyon, New Mexico. *Am Antiq* 1986;51(2):370–375.
- BIRKS HJB, GORDON AD. *Numerical methods in Quaternary pollen analysis*. London: Academic Press; 1985.
- BOTT B, BARTON H, SAMUEL D, TORRENCE R. *Biology of starch*. In: TORRENCE R, BARTON H, editors. *Ancient starch research*. Walnut Creek (CA): West Coast Press; 2006. p 35–45.
- CAMPBELL DG, FORD A, LOWELL KS, WALKER J, LAKE JK, OCAMPO-RAEDER C, TOWNESMITH A, BALICK M. The feral forests of the Eastern Petén. In: BALÉE W, ERICKSON CL, editors. *Time and complexity in historical ecology*. New York: Columbia University Press; 2006. p 21–55.
- CHANDLER-EZELL K, PEARSALL DM, ZEIDLER JA. Root and tuber phytoliths and starch grains document manioc (*Manihot esculenta*), arrowroot (*Maranta arundinacea*), and *Ilerén* (*Calathea* sp.) at the Real Alto site, Ecuador. *Econ Bot* 2006;60:103–120.

- DENHAM T, BARTON H. The emergence of agriculture in New Guinea. In: KENNETT DJ, WINTERHALDER B, editors. Behavioral ecology and the transition to agriculture. Berkeley: University of California Press; 2006. p 237–264.
- DENHAM T, HABERLE S. Agricultural emergence and transformation in the Upper Wahgi valley, Papua New Guinea, during the Holocene: theory, method, and practice. *Holocene* 2008;18:481–496.
- DIETLER M. Driven by drink: the role of drinking in the political economy and the cast of early Iron Age France. *J Anthropol Archaeol* 1990;9:352–406.
- DIETLER M. Feasts and commensal politics in the political economy: food, power and status in prehistoric Europe. In: WIESSNER P, SCHIEFENHOVEL W. Food and the Status Quest. Providence (RI): Berghahn; 1996. p 87–125.
- DIETLER M. Culinary encounters: food, identity, and colonialism. In: TWISS KC, editor. The archaeology of food and identity. Occasional paper 34. Carbondale (IL): Center for Archaeological Investigations, Southern Illinois University; 2007. p 218–242.
- DIETLER M, HAYDEN B, editors. Feasts: archaeological and ethnographic perspectives on food, politics, and power. Washington (DC): Smithsonian Institution Press; 2001.
- ERICKSON CL. The domesticated landscapes of the Bolivian Amazon. In: BALÉE W, ERICKSON CL, editors. Time and complexity in historical ecology. New York: Columbia University Press; 2006. p 235–278.
- FAEGRI K, KALAND PE, KRZYWINSKI K. Textbook of pollen analysis. 4th ed. Chichester: Wiley; 1989.
- FORD A. Dominant plants of the Maya Forest and Gardens of El Pilar: implications for paleoenvironmental reconstructions. *J Ethnobiol* 2008;28:179–199.
- FORD A, EMERY KF. Exploring the legacy of the Maya Forest. *J Ethnobiol* 2008;28:147–153.
- FRANKLIN M. The archaeological dimensions of soul food: interpreting race, culture, and Afro-Virginian identity. In: ORSER CE, JR, editor. Race and the archaeology of identity. Foundations of Archaeological Inquiry. Salt Lake City: University of Utah Press; 2001. p 88–107.
- FREDLUND GG, TIESZEN LT. Modern phytolith assemblages from the North American Great Plains. *J Biogeogr* 1994; 21:321–335.
- FULLAGAR R. Starch on artifacts. In: TORRENCE R, BARTON H, editors. Ancient starch research. Walnut Creek (CA): Left Coast Press; 2006. p 177–203.
- FULLER DQ. Ceramics, seeds and culinary change in prehistoric India. *Antiquity* 2005;79(306):761–777.
- GASSER RE, KWIAKOWSKI SM. Regional signatures of Hohokam plant use. *Kiva* 1991;56(3):207–226.
- GIFFORD-GONZALEZ D, SUNSERI KU. Foodways on the frontier: animal use and identity in early Colonial New Mexico. In: TWISS KC, editor. The archaeology of food and identity. Occasional paper 34. Carbondale (IL): Center for Archaeological Investigations, Southern Illinois University; 2007. p 260–287.
- GOLDSTEIN D. Forests and fires: a paleoethnobotanical assessment of the impact of Middle Sicán pyrotechnology. On the dry tropical forests of the La Leche River valley, Lambayeque, Peru (950–1050 C.E.) [PhD dissertation]. Carbondale (IL): Department of Anthropology, Southern Illinois University; 2007.
- HARDY K. Food for thought: starch in Mesolithic diet. *Mesolith Misc* 2007;18(2):2–11.
- HART JP, MATSON RG. The use of multiple discriminant analysis in classifying prehistoric phytolith assemblages recovered from cooking residues. *J Archaeol Sci* 2009;36:74–83.
- HASTORF CA. Introduction to cultural meanings. In: JOHANNESSEN S, HASTORF CA, editors. Corn and culture in the prehistoric New World. Minnesota Anthropology Series. Boulder (CO): Westview Press; 1994. p 395–398.
- HASTORF CA. Cultural implications of crop introductions in Andean prehistory. In: GOSDEN C, HATHER J, editors. The prehistory of food, appetites for change. London: Routledge; 1999. p 35–58.
- HASTORF CA. Domesticated food and society in Early Coastal Peru. In: BALÉE W, ERICKSON C, editors. Time and complexity in historical ecology: studies in the Neotropical Lowlands. New York: Columbia University Press; 2006. p 87–126.
- HASTORF CA, JOHANNESSEN S. Pre-Hispanic political change and the role of maize in the central Andes of Peru. *Amer Anthropol* 1993;95(1):115–138.
- HENRY AG, PIPERNO DR. Using plant microfossils from dental calculus to recover human diet: a case study from Tell al-Raqa'i, Syria. *J Archaeol Sci* 2008;35:1943–1950.
- HENRY A, HUDSON H, PIPERNO D. Changes in starch grain morphologies from cooking. *J Archaeol Sci* 2009;915–922.
- HOBBSAWM E, RANGER R, editors. The invention of tradition. CANTO ed. Cambridge: Cambridge University Press; 1992.
- HORROCKS M, RECHTMAN RB. Sweet potato (*Ipomoea batatas*) and banana (*Musa* sp.) microfossils in deposits from the Kona field system, Island of Hawaii. *J Archaeol Sci* 2009;36:1115–1126.
- HORROCKS M, IRWIN G, JONES M, SUTTON D. Starch grains and xylem cells of sweet potato (*Ipomoea batatas*) and bracken (*Pteridium esculentum*) in archaeological deposits from northern New Zealand. *J Archaeol Sci* 2004;31:251–258.
- INGOLD T. The temporality of the landscape. *World Archaeol* 1993;25:152–174.
- JACOMET S, editor. Palaeoethnobotany at the time of the Tyrolean Iceman. Special issue. *Veg Hist Archaeobot* 2009;18(1).
- JOHANNESSEN S, HASTORF CA. Expanding perspectives on prehistoric people/plant relationships. In: PREUCEL RW, HODDER I, editors. Contemporary archaeology in theory. Oxford: Blackwell Press; 1996. p 61–78.
- JONES G. Interpretation of archaeological plant remains: ethnographic models from Greece. In: VAN ZEIST W, CASPARIE W, editors. Plants and ancient Man. Studies in Paleoethnobotany. Rotterdam: Balkema; 1984. p 43–59.
- JONES G. A statistical approach to the archaeological identification of crop processing. *J Archaeol Sci* 1987;14:311–323.

- JONES M. Feast: why humans share food. Oxford: Oxford University Press; 2007.
- JONES G, HALSTEAD P. Maslins, mixtures, and monocrops: on the interpretation of archaeobotanical crop samples of heterogeneous composition. *J Archaeol Sci* 1995; 22:103–114.
- KENNETT DJ, VOORHIES B, MARTORANA D. An ecological model for the origins of maize-based food production on the Pacific coast of southern Mexico. In: KENNETT DJ, WINTERHALDER B, editors. Behavioral ecology and the transition to agriculture. Berkeley: University of California Press; 2006. p 103–136.
- KIRCH PV. Three islands and an archipelago: reciprocal interactions between humans and island ecosystems in Polynesia. *Earth Environ Sci Trans Roy Soc Edinburgh* 2007;98:85–99.
- KIRCH PV, COIL J, HARTSHORN AS, JERAJ M, VITOUSEK PM, CHADWICK OA. Intensive dryland farming on the leeward slopes of Haleakala, Maui, Hawaiian Islands: archaeological, archaeobotanical, and geochemical perspectives. *World Archaeol* 2005;37:240–258.
- KUBIAK-MARTENS L. The plant food component of the diet at the late Mesolithic (Ertebølle) settlement at Tybrind Vig, Denmark. *Veg Hist Archaeobot* 1999;8(1–2):117–127.
- KUBIAK-MARTENS L. New evidence for the use of root foods in pre-agrarian subsistence recovered from the late Mesolithic site at Halsskov, Denmark. *Veg Hist Archaeobot* 2002;11:23–31.
- LECOUNT L. Like water for chocolate: feasting and political ritual among the Late Classic Maya of Xunantunich, Belize. *Amer Anthropol* 2001;103(4):935–953.
- LENTZ DL, YAEGER J, ROBIN C, ASHMORE W. Pine, prestige and politics of the Late Classic Maya at Xunantunich, Belize. *Antiquity* 2005;79(305):573–585.
- LEV-TOV J, MCGOUGH K. Feasting at Late Bronze Age Hazor as political and religious identity expression. In: TWISS K, editor. We are what we eat: archaeology, food and identity. Carbondale: Southern Illinois University Press; 2007. p 85–111.
- LOY TH, SPRIGGS M, WICKLER S. Direct evidence for human use of plants 28,000 years ago: starch residues on stone artefacts from the northern Solomon Islands. *Antiquity* 1992;66:898–912.
- LU H, ZHANG J, WU N, KIU K-B, XU D, LI Q. Phytoliths analysis for the discrimination of foxtail millet (*Setaria italica*) and common millet (*Panicum miliaceum*). *PLoS ONE* 2009;4(2):e4448.
- LYONS D, D'ANDREA AC. Griddles, ovens and the origins of agriculture: an ethnoarchaeological study of bread baking in Highland Ethiopia. *Amer Anthropol* 2003;105(3):515–530.
- MADELLA M, editor. Environmental archaeology. Oxford: Oxbow Books; 2007.
- MADELLA M, ZURRO D, editors. Plants, people, and places. Recent studies in phytolith analysis. Oxford: Oxbow Books; 2007.
- MATTHEWS WC, FRENCH T, LAWRENCE D, CUTLER F, JONES MK. Micromorphological traces of site formation processes and human activities. *World Archaeology* 1997;29(2):281–308.
- MESSER E. Three centuries of changing European taste for the potato. In: MACBETH H, editor. Food preferences and taste. Oxford: Berghahn Books; 1997. p 101–113.
- MIKSICEK C. Formation processes of the archaeobotanical record. *Adv Archaeol Meth Theory* 1987;10:211–247.
- MILLER N. What mean these seeds: a comparative approach to archaeological seed analysis. *Hist Archaeol* 1989;23:50–59.
- MOORE PD, WEBB JA, COLLINSON ME. Pollen analysis. 2nd ed. Oxford: Blackwell; 1991.
- NEFF H, PEARSALL DM, JONES JG, ARROYO B, COLLINS SK, FREIDEL DE. Early Maya adaptive patterns: Mid–Late Holocene paleoenvironmental evidence from Pacific Guatemala. *Lat Amer Antiq* 2006;17:287–315.
- OEGL K. The significance of the Tyrolean Iceman for the archaeobotany of Central Europe. *Veg Hist Archaeobot* 2009;18(1):1–11.
- PEARSALL DM. Paleoethnobotany. A handbook of procedures. 2nd ed. Walnut Creek (CA): Left Coast Press; 2000 (2010) [note that this is not a new edition, but a new printing that the press has listed as 2010].
- PEARSALL DM. Plants and people in ancient Ecuador: the ethnobotany of the Jama River Valley. Case Studies in Archaeology Series. Belmont (CA): Wadsworth/Thomson Learning; 2004.
- PEARSALL DM. Modeling prehistoric agriculture through the palaeoenvironmental record: theoretical and methodological issues. In: DENHAM T, IRIARTE J, VRYDAGHS L, editors. Rethinking agriculture: archaeological and ethnoarchaeological perspectives. Walnut Creek (CA): Left Coast Press; 2007. p 210–230.
- PEARSALL DM, CHANDLER-EZELL K, ZEIDLER JA. Maize in ancient Ecuador: results of residue analysis of stone tools from the Real Alto site. *J Archaeol Sci* 2004;31:423–442.
- PERRY L. Starch analyses reveal the relationship between tool type and function: an example from the Orinoco valley of Venezuela. *J Archaeol Sci* 2004;31:1069–1081.
- PERRY L. Reassessing the traditional interpretation of “manioc” artifacts in the Orinoco Valley of Venezuela. *Lat Amer Antiq* 2005;16:409–426.
- PIPERNO DR. The status of phytolith analysis in the American tropics. *J World Prehist* 1991;5:155–191.
- PIPERNO DR. Plant microfossils and their application in the New World tropics. In: STAHL PW, editor. Archaeology in the lowland American tropics: current analytical methods and recent applications. Cambridge: Cambridge University Press; 1995. p 130–153.
- PIPERNO DR. The origins of plant cultivation and domestication in the Neotropics. In: KENNETT DJ, WINTERHALDER B, editors. Behavioral ecology and the transition to agriculture. Berkeley: University of California Press; 2006a. p 137–166.
- PIPERNO DR. Phytoliths: a comprehensive guide for archaeologists and paleoecologists. Landam (MD): AltaMira Press; 2006b.
- PIPERNO DR. Identifying crop plants with phytoliths (and starch grains) in Central and South America: a review

- and an update of the evidence. *Quatern Int* 2009;193:146–159.
- PIPERNO DR, DILLEHAY TD. Starch grains on human teeth reveal early broad crop diet in northern Peru. *Proc Natl Acad Sci* 2008;105:19622–19627.
- PIPERNO DR, HOLST I. The presence of starch grains on prehistoric stone tools from the humid Neotropics: indications of early tuber use and agriculture in Panama. *J Archaeol Sci* 1998;25:765–776.
- PIPERNO DR, JONES JG. Paleoeological and archaeological implications of a Late Pleistocene/Early Holocene record of vegetation and climate from the Pacific coastal plain of Panama. *Quatern Res* 2003;59:79–87.
- PIPERNO DR, PEARSALL DM. The origins of agriculture in the Lowland Neotropics. San Diego (CA): Academic Press; 1998.
- STAHL AB. Plant-food processing: implications for dietary quality. In: HARRIS D, HILLMAN G, editors. *Foraging and farming*. London: Unwin and Hymen; 1989. p 171–194.
- TIPPING R. “Ritual” floral tributes in the Scottish Bronze Age-Palynological evidence. *J Archaeol Sci* 1994; 21: 133–139.
- TORRENCE R. Starch in sediments. In: TORRENCE R, BARTON H, editors. *Ancient starch research*. Walnut Creek (CA): Left Coast Press; 2006. p 145–176.
- TORRENCE R, WRIGHT R, CONWAY R. Identification of starch granules using image analysis and multivariate techniques. *J Archaeol Sci* 2004;31:519–532.
- TWISS K. Home is where the hearth is: food and identity in the Neolithic Levant. In: TWISS K, editor. *We are what we eat: archaeology, food and identity*. Carbondale: Southern Illinois University Press; 2007. p 50–68.
- TWISS P, SUESS E, SMITH R. Morphological classification of grass phytoliths. *Soil Sci Soc Am Proc* 1969; 33:109–115.
- VALAMOTTI S-M, SAMUEL D, BAYRAM M, MARINOVA E. Prehistoric cereal foods from Greece and Bulgaria: investigation of starch microstructure in experimental and archaeological charred remains. *Veg Hist Archaeobot* 2008; 17(Suppl):S265–276.
- VAN DER VEEN M. Formation processes of desiccated and carbonized plant remains: the identification of routine practice. *J Archaeol Sci* 2007;34:968–990.
- VAN DER VEEN M. Food as embodied material culture: diversity and change in plant food consumption in Roman Britain. *J Rom Archaeol* 2008;21:83–109.
- WANDSNIDER L. The roasted and the boiled: food composition and heat treatment with special emphasis on pit-hearth cooking. *J Anthropol Archaeol* 1997;16:1–48.
- WEISS E, KISLEV ME, SIMCHONI O, NADEL D, TSCHAUNER H. Plant-food preparation area on an Upper Paleolithic brush hut floor at Ohalo II, Israel. *J Archaeol Sci* 2008;35: 2400–2414.
- WILLIAMSON BS. Middle Stone Age tool function from residue analysis at Sibudu Cave. *S Afr J Sci* 2004;31:174–178.
- WOLLSTONECROFT M, ELLIS PR, HILLMAN GC, FULLER DQ. Advances in plant food processing in the Near Eastern epipaleolithic and implication for improved edibility and nutrient bioaccessibility: an experimental assessment of *Bolboschoenus maritimus* (L.) Palla (sea club-rush). *Veg Hist Archaeobot* 2008;17S:19–27.
- WRIGHT P. Flotation samples and some paleoethnobotanical implications. *J Archaeol Sci* 2005;32(1):19–26.
- ZARRILLO S, KOOYMAN B. Evidence for berry and maize processing on the Canadian Plains from starch grain analysis. *Am Antiq* 2006;71:473–499.
- ZARRILLO S, PEARSALL DM, RAYMOND JS, TISDALE MA, QUON DJ. Directly dated starch residues document Early Formative maize (*Zea mays* L.) in tropical Ecuador. *Proc Natl Acad Sci* 2008;105:5006–5011.
- ZHAO Z, PEARSALL DM. Experiments for improving phytolith extraction from soils. *J Archaeol Sci* 1998;25:587–598.
- ZHAO Z, PEARSALL DM, BENFER RA, JR, PIPERNO DR. Distinguishing rice (*Oryza sativa* Poaceae) from wild *Oryza* species through phytolith analysis. II: Finalized method. *Econ Bot* 1998;52:134–145.
- ZONG Y, CHEN Z, INNES JB, CHEN C, WANG Z, WANG H. Fire and flood management of coastal swamp enabled first rice paddy cultivation in east China. *Nature* 2007;449:459–462.

Chapter 12

History and Current Trends of Ethnobiological Research in Europe

INGVAR SVANBERG

Uppsala Centre for Russian and Eurasian Studies, Uppsala University, Uppsala, Sweden

ŁUKASZ ŁUCZAJ

Department of Ecotoxicology, University of Rzeszów, Werynia, Kolbuszowa, Poland

MANUEL PARDO-DE-SANTAYANA

Department of Botany, University of Madrid, Madrid, Spain

ANDREA PIERONI

University of Gastronomic Sciences, Pollenzo/Bra, Italy

HISTORY OF A DISCIPLINE	191
THE RECORDING MAN	191
NATURAL HISTORY DURING THE RENAISSANCE	192
EIGHTEENTH CENTURY: THE BEGINNING OF ECONOMIC BOTANY	193
MEDICINAL PLANTS AND ECONOMIC BOTANY	194
NINETEENTH CENTURY: EXPLORERS AND ARMCHAIR SCHOLARS	195
EARLY TWENTIETH CENTURY: ETHNOGRAPHICAL STUDIES	197
POPULAR MEDICINE	200
FOLKLORE AND PLANT NAME RESEARCH	201
BOTANISTS ON PLANT USE	202
ENCOUNTERS BETWEEN HUMAN AND NONHUMAN ANIMALS	204
TOWARDS A SCIENCE OF ETHNOBIOLOGY IN EUROPE SINCE 1980	204
CURRENT TRENDS	205
REFERENCES	208

We who belong to today's post-industrial society can sometimes have difficulty in imagining how close to the surrounding landscape rural people lived in pre-industrial Europe only a few generations ago. Trapping, transhumance livestock keeping, gathering of fodder and haymaking as well as hand-crafting utensils for the household meant that forest settings and mountain areas were not wildernesses, but multi-faceted production landscapes, which locals from childhood learned to interpret, use and transform. They knew their forest or mountains well.

Inhabitants of local, traditional societies, whether in the case of livestock herdsman in mountainous areas of southeastern Europe in the early twentieth century, or contemporary slash-and-burn agriculturalists of the Amazon rainforest, devoted a lifetime to learning to master the local environments on which they were dependent for their livelihood. Claude Lévi-Strauss has revealed that local populations typically have an excellent familiarity with the biological environment, and they show a passionate attention to it (Lévi-Strauss 1962).

This understanding of what Lévi-Strauss calls “science of the concrete” includes not only those organisms and contexts which reflect cultural, economic, and medicinal needs, but also deep and detailed knowledge of the environment in general. Therefore, mountain herdsman in the Balkan Peninsula, farm workers in Calabria, fishermen in Atlantic islands, rural cultivators in Central Europe, villagers in the vast marshlands of the Great Hungarian Plain, forest-cutters in the northern Iberian Peninsula, peasant hunters in central Scandinavia, or reindeer nomads in the Sápmi are at least as interesting to study in terms of their folkbiological knowledge as the Kayapó, Naulu, Ntlakyapamuk, or Piman.

Ethnobiologists in Europe work to get rid of the widely held notion that ethnobiology is all about “non-Western people.” European rural people are part of our professional realm.



Figure 12.1 Albanian women from Kelmendi in the northern Albanian Alps smelling spignel (*Meum athamanticum*), which is locally used as a cosmetic plant. Photograph courtesy of Andrea Pieroni. (See color insert.)

As ethnobiologists we usually study rural people's ecological knowledge in societies with high levels of self-sufficiency. We study the biocultural domains that develop in the interactions between human beings and their surrounding landscape, including perceptions of the biota, local management, and use of biological resources (Pardo-de-Santayana et al. 2010).

HISTORY OF A DISCIPLINE

Overviews of the development of the sciences of ethnobotany and ethnobiology usually stress North American contributions to the subject. Ancient Greek and Roman writers are sometimes mentioned, but seldom do we read about important eighteenth to early twentieth century scholars in other parts of the world. The history of an academic discipline is a highly subjective matter; for ethnobiology it is very much so (Clément 1998; Ford 1978; Hunn 2007).

This bias in the historiography of our discipline is to a large extent a question of understanding languages other than English. Little information is to be found in international overviews. Only C.M. Cotton (1996) provides a brief overview of the European contribution to the development of ethnobotany and ethnopharmacology.

Although the terms “ethnobotany,” “ethnozoology,” “ethnobiology,” and “ethnoecology” were not coined until 1895, 1899, 1935, and 1954 respectively, the history of the ethnobiological field began in Europe long before then. Even though this type of research did not develop early into a separate academic discipline, over the centuries many European scholars within botany, ecology, ethnology, human geography, pharmacology, and zoology, as well as advanced amateurs, have made important contributions to the field of ethnobiology.

The Recording Man

In every ancient culture with a written language, people have recorded useful knowledge about animals, plants, and environments. This is particularly true of medicinal discoveries and knowledge. Some of these texts have been preserved. We have Assyrian, Egyptian, and Greek medicinal books which bear witness to extensive knowledge about how animal and plant products could be utilized (cf. Raven 2000).

Greek and Roman authors reported, for instance, on the importance of the acorn (*Quercus*) for bread, the use of medicinal plants such as *herba vettonica* (*Stachys officinalis*), or the ingestion of yew (*Taxus baccata*) as a poison in the Mediterranean by old people no longer able to fight. The physician Pedanius Dioscorides (AD 40–90) wrote *Περί ὕλης ἰατρικῆς* “On medical material”—better known in its Latin translation *De materia medica*—which remained important until today. Dioscorides described in detail more than 600 medicinal plants and also included medicines made from animals and minerals. He also recorded ancient local plant names from various tribes.

His contemporary Pliny de Elder's (AD 23–79) encyclopedic *Naturalis historia* “Natural history” is another important written source for our knowledge about animals and plants among the Romans. Pliny provides a wealth of interesting information, such as that hedgehog skin was used in dressing cloth for garments, ravens were taught to imitate human voices, and dolphins assisted fishermen in catching fish.

Natural History during the Renaissance

In medieval herbals of the thirteenth century, the ancient tradition of medicinal plants lived on with some additions of newer data. In Andalusia, Arab scientist Ibn Al-Baytar (ca. 1180–1248) compiled a book of food and medicinal plants, based on his own observations and more than 200 sources (including Dioscorides), presenting uses for 1400 simples.

With the invention and diffusion of Gutenberg’s printing press in the late fifteenth century it became possible to publish herbals in larger editions, for instance Leonhart Fuchs’ herbal *Neu Kreüterbuch* (1543) which catalogues more than 400 plants native to Germany and Austria, as well as about 100 exotic plants. The German language version is nicely illustrated with woodcut prints. The book has been used widely in handbooks throughout plant cultural history as a source for knowledge about medicinal plants in former times. Other herbals, for example, by Henrick Smid (1546), William Turner (1551), Remberd Dodoens (1554), Andrés Laguna (1555), Pietro Andrea Mattioli (1568), Juhász Melius (1578), Marcin z Urzędowa (1595), John Gerard (1597), and Simon Syrennius (1613), were also widely read. We know little about the ethnographic background and field methods adopted at that time (many just copied data from others), and so it is probably not accurate to use the term “ethnobiology” to refer to all the herbals and overviews on plant uses in Europe, which were carried out centuries before the proper development of ethnography in the nineteenth century.

The Swiss zoologist Conrad Gessner’s (1516–1565) books on birds and fish are of importance for our understanding of faunal change in Europe, but they also include many notes regarding the uses of various taxa (Kinzelbach 2004). Peter Claussøn Friis’ (1545–1614) description of northern Norway published in 1632 describes Nordic conceptions of animal life at the end of the 1500s. A manuscript by Jón Guðmundsson the Learned (1574–1658) provides folk knowledge details about whales and fish in Iceland.

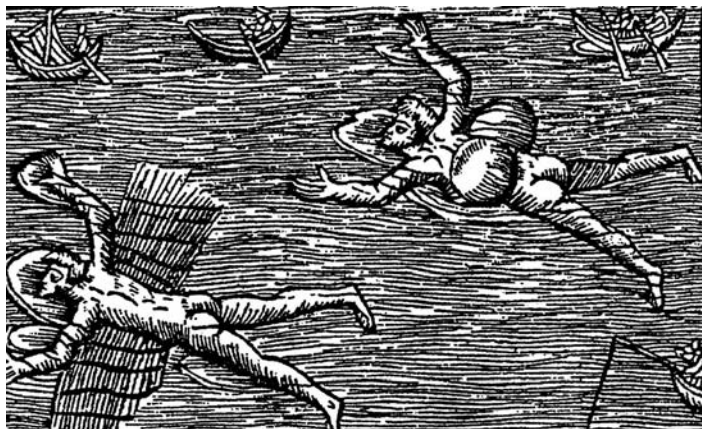


Figure 12.2 Olaus Magnus describes in 1555 how floats of reed (*Phragmites australis*) and club rush (*Schoenoplectus lacustris*) were used when boys in Scandinavia learned to swim. In the mid-1900s, it was still possible to document Swedish children learning to swim with floats made of this material. The technology is ancient, known to the Romans as *scirpus ratiae*. From Olaus Magnus, *Historia de gentibus septentrionalibus*, Roma; 1555.

BOX 12.1 *Saami Use of Bark as Food*

In 1673, an international bestseller with the title *Lapponia* was published. It was compiled by Johannes Schefferus, and describes the Saami people and their relationship with the surrounding landscape. More important for ethnobiologists are the accounts which had furnished the basis for Schefferus' description of Lapland. These accounts, which were written in the 1670s by clergymen, some of Saami origin, are unequalled in quality and comprehensiveness. They provide a wealth of information on Saami methods of hunting, fishing, reindeer-herding, folk medicine, and wild-plant harvesting, and deserve further analysis. Samuel Rheen reports in detail in 1670, for instance, how the Saami utilized the inner bark of the pine (*Pinus sylvestris*) as food by preparing it wrapped in birch bark in the heat of a fire:

The Lapps also use pine bark for food, in particular the Lapps living in the forest region. This bark is called *Sautopetzi* [*savððuobiehtsie*], which they prepare as follows: they peel off the bark of large pine trees, particularly the bark near the root and clean it well, so that it looks like fine linen. This bark is dried in the sun, then cut into small pieces and then put into the big birch-bark slices, which they bury in the soil, covering it with sand and then light a large log fire above. The bark prepared thus is red and sweet, and they eat it as a confection."

This way of utilizing pine bark has been widespread among the Saami during centuries, and has been documented through a variety of sources in recent research.

Eighteenth Century: the Beginning of Economic Botany

Several authors, including Paul Alan Cox (2001) and E. Wade Davis (1995), have pointed to the importance of Carl Linnaeus for the development of ethnobiology.

During the mid-1700s a wealth of empirical data of interest for ethnobiologists was scientifically and systematically gathered by Linnaeus and his contemporaries. Linnaeus was an excellent fieldworker, and through his diaries we can follow his method in detail. In 1732, during a journey to Lapland, Linnaeus studied the knowledge possessed by the Saami about plants and animals. He never hesitated to approach farmers or reindeer herders, and made notes of both large and small matters (Svanberg 2002). For example, he recorded that young Saami men engaged in courting used the scented fungus *Haploporus odoros* as a fragrance. In his *Flora lapponica* from 1737 he noted that Saami bachelors stored

it carefully in a pouch furthest down on their stomach, in order the sweet fragrance it sends forth might make them more pleasing to their nymphs. Oh you ridiculous Venus, who in foreign lands have at your service coffee and chocolate, sweets and preserves, wines and lemonades, precious stones and pearls, gold and silver, silks and pomades, dancing and feasting, music and merrymaking! Here you must content yourself with a tasteless fungus.

From his travels in Dalecarlia in 1734 Linnaeus reported on the long-distance trade in medicinal plants. The roots of bitterwort (*Gentiana purpurea*) were imported by peasant peddlers into Sweden from Norway. This trade can be traced back to the early sixteenth century. It was gathered by farmers in the vicinity of Valdres. The trade continued for generations, but eventually the excessive demand and the growing scarcity and local extirpation of the plant in Norway brought it to an end (Svanberg 2001b).

The purpose of Linnaeus's research was to document the gifts left by the Creator in Nature. Linnaeus was genuinely interested in learning from the people. He looked closely at traps and fishing implements; he tasted the food prepared by reindeer herders, and he

inquired about household remedies; he peered into barns to see how vermin were being kept away; and he asked old women about the folk names of plants. Although Linnaeus's travelogues provide us with many first-hand observations of great interest we do not agree that he was the "father of ethnobotany." It is probably more correct to label him a bioprospector or economic botanist, because he had little interest in the data in context.

Linnaeus's travelogues became exemplars for a whole generation of scholars and developed into an international genre of topographical works including information of ethnobotanical and ethnozoological interest. Peter Kalm (1716–1779) gathered a lot of valuable first-hand information in southwestern Sweden (1741), Russia (1744), and North America (1749–1752), while Johan Peter Falck (1732–1774), who headed an expedition into Siberia and the Kazak steppe (1768–1774), made recordings about animal and plant knowledge among Turkic and Finno-Ugric peoples in Russia (Svanberg 1987).

We can also mention Jens Christian Svabo (1746–1824) on the Faroes, John Lightfoot (1735–1788) in Scotland, José Quer y Martínez (1695–1764) in Spain, and Félix de Avelar Brotero (1744–1828) in Portugal. In Poland the priest Krzysztof Kluk (1739–1796) devoted his life to the study of economic botany. His *Dykcyonarz Roślinny* "Plant Dictionary" was an alphabetic encyclopedia of plant uses both copied from other authors and observed from his area.

For this generation of scientists, folk knowledge of plants and animals was a storehouse of information which scholars could draw upon. The empiric data from these travelers were devoted to improving a nation's and a people's quality of life and health. Passed down in the literature, the Linnaean tradition is part of our shared knowledge of plant use today. It has also been exploited in various contexts for economic development and social change (Nelson and Svanberg 1987).

Past travelers reported on the ritual use of the hallucinogenic fly agaric (*Amanita muscaria*) by shamans in northeastern Siberia. Reading these reports, the Swedish clergyman Samuel Ödmann published in 1784 an article which could be described as an attempt to use ethnomycological observations to explain the so-called berserker rages among the Vikings. According to Ödmann they used fly agaric. However, there are no historical sources or pieces of archaeomycological evidence that the Vikings actually used fly agaric. It is interesting though, that the notion has become widespread, and Ödmann's report later inspired ethnomycologist R. Gordon Wasson (1898–1986) in his search for soma and magic mushrooms.

Medicinal Plants and Economic Botany

Searching for new drugs is not a primary goal among contemporary ethnobiologists, but it has been part of the European scholars' interest in economic plants since Linnaeus's time. During his travels in the Swedish countryside Linnaeus observed how peasants used the marsh rosemary (*Rhododendron tomentosum*) against various ailments among small livestock and human beings. As a physician, he tried the plant in human medicine and in a dissertation from 1775 he praises marsh rosemary as a remedy against scurvy, whooping cough, laryngitis, and leprosy. The Linnaeans and their contemporaries showed great confidence in finding new medicaments among peasant folk-medicine.

More famous, and often given as an example in textbooks, is the physician William Withering, who observed how a local female healer in Shropshire achieved good results by treating patients suffering from edema with an herbal remedy. Withering examined the herb composition and through deduction found that it must have been the foxglove

(*Digitalis purpurea*), which was medically active. He prepared an extract of the plant and examined its effect on patients. The treatment proved successful in reducing fluid build-up in the tissues by its effects on the heart. Trials were extended to more patients. Withering published his results in 1785 (Balick and Cox 1996).

Nineteenth Century: Explorers and Armchair Scholars

From the mid-nineteenth century—a time of increasing Western scientific explorations in the world—and onwards, interest increased in documenting folk knowledge and uses of wild plants and animals. Most of these are entries and passages in travelogues and ethnographical monographs, but there were also what could be regarded as proto-ethnobiological studies. Clergyman and local historian Johann Wilhelm Ludwig Luce (1756–1842) compiled a *Heilmittel der Ehsten auf der Insel Oesel* “Remedies among the Estonians of the island Saarema” (1829), one of the first systematic medico-ethnobotanical accounts within a specific area in Europe.

Swiss botanist Pierre Edmond Boissier (1810–1885) traveled through the Iberian Peninsula. Boissier noted that the shepherds of Sierra Nevada collected the endemic *Artemisia granatensis* to sell in the city of Granada. The herb was considered a panacea. Modern ethnobotanical studies have also registered its use and marketing in the area. The species was officially protected in 1982, since the high demand led to the threat of extinction (Pardo-de-Santayana and Morales 2010). German scholar Ludwig Hopf (1838–1924) published an in-depth analysis based on a huge amount of comparative material on animals used as oracles and omens from various times and in various parts of the world. The author analyses these data from what he calls an “ethnological–zoological” perspective. Rudolph Krebel gave an account of folk-medicine among various ethnic groups in the Russian Empire from 1856. Johann Georg Dragendorff (1836–1898) in Tartu published *Die Heilpflanzen der verschiedenen Völker und Zeiten* “Medicinal Plants of Various Peoples and Times” (1898), in which he described the use of many species. Czech ethnographer Primus Sobotka (1841–1925) published in 1879 a book containing rich material concerning the folk beliefs about plants in Slavic countries.

The new currents of interest in aboriginal botany in North America did not pass unnoticed in Europe. During the Vega Expedition that travelled the North East Passage in 1878–1879, the ship was trapped in the ice for many months outside a Chukchee village. To get voucher specimens for his botanical collection, the expedition member Frans Reinhold Kjellman (1846–1907) asked the native Chukchee in the vicinity about food and household plants. After the expedition returned to Sweden, Kjellman, who was aware of the American studies, published in 1882 his findings, including both theoretical and methodological discussions.

“What people think about sickness and health, to what cause they ascribe their physical suffering, and what remedies they use, in order to cure or prevent illness, is derived from their medical knowledge, their folk medicine,” wrote physician Leopold Glück (1856–1907). He worked in Sarajevo and gathered folk remedies in Bosnia and Herzegovina at the end of the nineteenth century. Glück (1894) not only emphasized an emic perspective, but also gathered substantial material on traditional medicinal uses of plants among rural people. In his impressive study from 1894, he listed 108 taxa and their local medical uses in the region.

Ethnobiological studies in the modern sense were introduced in Europe by a few local scholars in the nineteenth century. For instance, Paolo Mantegazza (1831–1910) wrote in

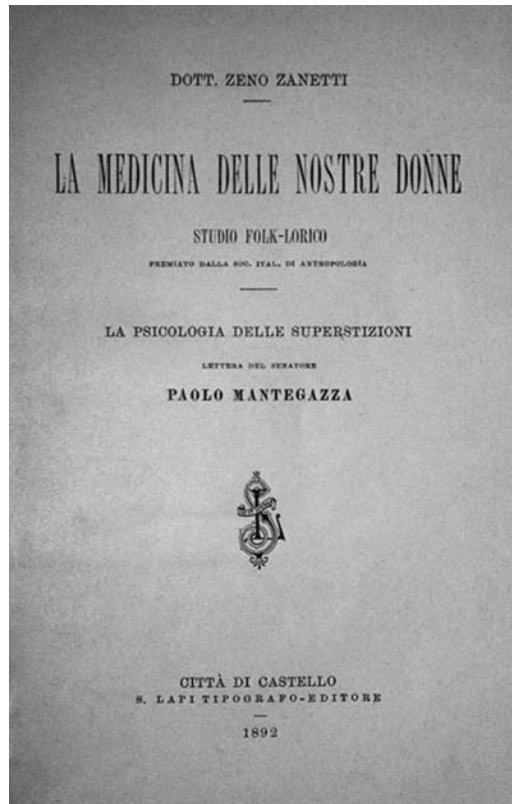


Figure 12.3 Front page of Zeno Zanetti's *La Medicina delle nostre donne* (1892).

1892 *La medicina delle nostre donne* “The medicine of our women,” where he documented a large number of folk-medicinal practices, a few of them also plant based. The first proper ethnobotanical study in Italy, however, was probably that of Giuseppe Ferraro (1845–1907), who described traditional plant uses in his home town of Carpeneto d’Acqui. In 1884 Ferraro listed traditional uses and folk names of dozens of plants. His introduction to this report represented an early attempt to conceptualize the importance of folk botanical studies, although a clear indication of the adopted methodology is missing from this study.

A few years later the prominent Sicilian folklorist Giuseppe Pitrè (1843–1916), in his *Medicina popolare siciliana* “Sicilian popular medicine” (1896), described many folk remedies still in use in various areas of Sicily. The approach in this work was more medico-anthropological: Pitrè listed various illnesses and wrote about different animal, vegetal, or even spiritual treatments. However, in this case too, the methodology was not clearly spelled out, and the research had more of the characteristics of an overview of information gathered from many folk sources.

In Poland, over a hundred publications on ethnobotanical topics appeared at the end of the nineteenth century. Oskar Kolberg (1814–1890) was an ethnographer who spent his life traveling around Poland writing down various aspects of local culture. He also noted local knowledge about plants, with many references to their medicinal, magical and food use. Józef Rostański (1850–1928) was a botanist from Cracow. In 1883, he issued through contemporary media his 70-question inquiry about the traditional use of plants. He received

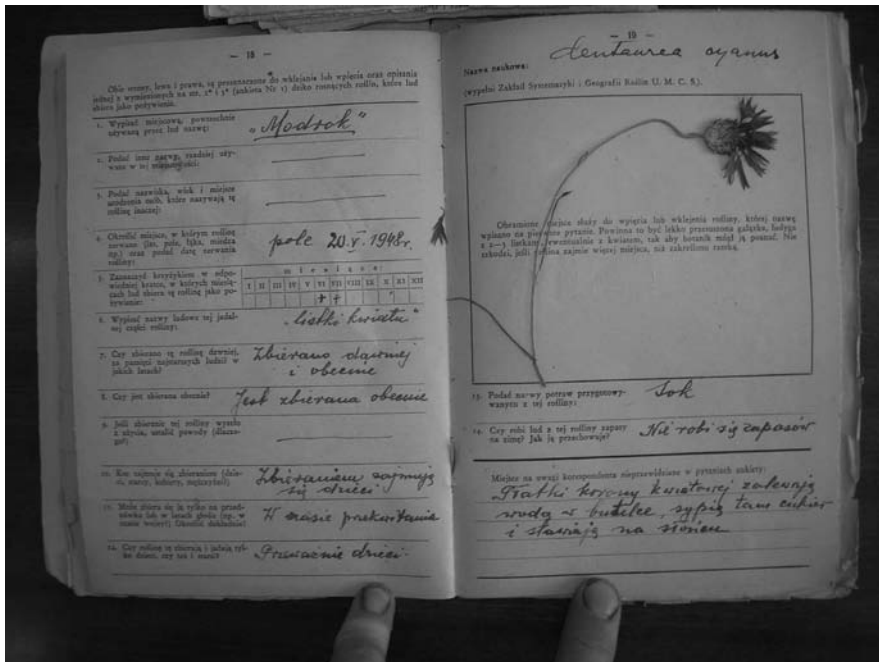


Figure 12.4 A questionnaire used by Józef Gajek in his 1948 study of wild food plants in Poland. The study was performed by volunteers who gathered freelists of wild food plants. A questionnaire like this was used to extract detailed information on the use of a particular species (in this case it is *Centaurea cyanus*, whose petals were widely used to make a refreshing fermented drink). His project provoked a response from over a hundred people: local teachers, priests, farmers, and even scouts. A year later a similar study was performed regarding medicinal plants. Courtesy of the archives of the Polish Ethnographic Atlas, Cieszyn; photo by Łukasz Łuczaj.

a few hundred letters from Poles inhabiting the present area of Poland, Ukraine, and Belarus. The results of his field material have only recently been published.

During the mid-nineteenth century, comprehensive fishery biological research was initiated in Scandinavia. Studies were based on fieldwork and were conducted in collaboration with fishermen along the coastal areas and lakes. Scholars recorded emic data like local names, information on old fishing methods, the population's knowledge and perceptions of the fish behavior and habitats, and data about the economic importance of local fish fauna. In 1896 questionnaires were distributed in Sweden in order to make a general inventory of the fauna of the thousands of lakes and rivers in the country. Only a fraction of this material is published, but today it offers an excellent source material for ethnozoological research.

Early Twentieth Century: Ethnographical Studies

While ethnobotany developed into its own scientific field in North America at the beginning of the twentieth century, it hardly got any following in Europe. The term itself was only occasionally used by European scholars before the 1980s (e.g., Borza 1931; Haudricourt 1956; Kowalska-Lewicka 1964; Moloney 1919; Nordenskiöld 1908). Those few European scholars who did dedicate themselves to ethnobotany, like Frenchman Jacques Barrau, undertook most of their research outside the continent (Barrau 1971). However, there were many European scholars within various fields (botany, ecology, ethnology, pharmacology)

who carried out substantial works that clearly qualify as important contributions to the field of ethnobiology, ethnobotany, and ethnozoology.

In 1908 the ethnographer Erland Nordenskiöld (1877–1932) compiled a manual for ethnographical fieldwork, in which he also discussed traditional knowledge of plants, and mentioned the word “ethnobotany” for the first time in Swedish. The manual was intended for Swedes, especially Christian missionaries, who lived and worked in distant lands. Nordenskiöld himself developed a collaboration with pharmacologist Carl Gustaf Santesson (1862–1939) for the analysis of poisons used by South American Indians. Santesson himself also collaborated with other ethnologists, and in 1939 he published an important analysis of the lichen *Letharia vulpina*, gathered from a Saami hunter who used it as a poison for killing wolves, an early study of ethnopharmacology (Holmstedt 1995).

Several researchers within cultural geography, such as John Frödin (1879–1960) in the 1920s to 1950s, published integrated, ecologically oriented studies of local resources and the role human activities played in landscape transformation in mountainous areas of Europe. These studies are similar to today’s problem-oriented ethnobiological research carried out in North America. They also provide a deeper historical dimension that is lacking in many modern studies. They stress both biological and socio-cultural perspectives.

BOX 12.2 *Blessed Bouquets*

The blessing of herbs and wild flowers in churches used to have a high cultural value in Poland and some other Catholic countries. The blessed plants were later used to heal people and animals and in magic rituals (smudging ill individuals, burning to protect from thunderstorm, hanging in prominent places in the house, etc.). The tradition arose as a mixture of Catholic liturgy and pre-Christian beliefs.

In Poland flowers are blessed twice. On the eighth day after Corpus Christi, called *Oktawa Bożego Ciała* (usually in mid-June) small wreaths of plants are blessed (e.g., *Asarum europaeum*, *Thymus* spp., *Fragaria vesca*, *Potentilla* spp., *Sedum acre*, *Trifolium* spp., *Rosa* spp.). On the day of the Assumption of the Virgin Mary (15 August, called *Matka Boska Zielna*, i.e., *Mary of Herbs*) there tend to be larger bouquets. Apart from wild herbs (*Hypericum perforatum*, *Achillea millefolium*, *Tanacetum vulgare*), they must include shoots of cereals, dill, an apple on a stick, some vegetables (e.g., onion or garlic), some forest fruits (*Viburnum opulus*, *Sorbus aucuparia*, *Corylus avellana*) and garden herbs (*Calendula officinalis*, *Salvia officinalis*, etc.).

Seweryn Udziela was an ethnographer who spent his life studying the folk customs of the Cracow area. Between 1894 and 1899 he gathered

detailed information on the composition of Assumption Day bouquets in 13 villages south of Cracow. The results of his study were published in 1931. Although we do not know the methods he used (e.g., how many bouquets were studied) he documented his research using voucher specimens and wrote down which plants were used in the bouquets in each village. His herbarium is stored as a special collection of the Herbarium of the Institute of Botany of the Polish Academy of Sciences. Udziela also studied children’s toys made of plants—the results were published in a separate article from 1929. As early as in 1883 another scholar from Cracow, Józef Rostafiński, issued a detailed 70-question ethnobotanical questionnaire concerning all aspects of plant use, published in several Polish newspapers at the time. One of the questions also concerned the composition of the blessed bouquets. Recently Łukasz Łuczaj surveyed the composition of bouquets brought to churches using digital photo close-ups. This technique allows rapid acquisition of high quality data and will make it possible to compare future changes of bouquet composition. In 2008 in many rural areas the bouquets still have a similar composition to those from Udziela’s nineteenth century study, but gradually garden flowers are replacing wild herbs.



Figure 12.5 A herbal bouquet from Stary Żmigród (the Beskid Niski Mountains). Such bouquets are still brought to Polish churches on Assumption Day (15 August). They are believed to acquire a healing and magical power. Photograph courtesy of Łukasz Łuczaj. (See color insert.)

Kazimierz Moszyński (1887–1959) was a Polish ethnographer, originally trained as a biologist. His *Kultura ludowa Słowian* “Folk culture of Slavs” (1929–1939) includes many pages on plants used in food, dyes, medicine, and magic, as well as beliefs concerning animals. He also attempted to create the first Polish ethnographic atlas in the 1930s, including an ethnobotanical question about apotropaic plants used during midsummer night celebrations (June 22). After World War II, ethnographer Józef Gajek (1907–1987) planned the compilation of a Polish ethnographic atlas. Ethnobotanical questionnaires were distributed throughout the country. This study is richly documented with voucher specimens and used freelisting, without pre-suggesting the use of any species (Łuczaj 2008).

Uses of plants in calendaric rites, festivals, folk beliefs, and household economy have been studied by many ethnologists. Plants as religious and social symbols are analyzed by British anthropologist Jack Goody in *The Culture of Flowers* (1993). Phebe Fjellström published a comparative study on the use of garden angelica (*Angelica archangelica*) among the Saami and the Scandinavians (Fjellström 1964). Gustav Ränk in the early 1960s studied the use of the insectivorous butterwort (*Pinguicula vulgaris*) to curdle milk, and the custom of the divining rod. Garðar Guðmundsson (1996) studied the harvest of lyme-grass (*Leymus arenarius*) for food in Iceland, Tamas Grynaeus (2001) wrote on the importance of the houseleek (*Sempervivum tectorum*) as a medicinal plant in Hungary, and Ida Eichelter-Sennhauser examined the use of plants in Austrian popular religion. Holger

Rasmussen (1975) has written a monograph on the Danish early spring traditional custom of gathering sweet woodruff (*Asperula odorata*) and making it into green wreaths. The cultural and economic importance of cloudberry (*Rubus chaemaemorus*) and cowberries (*Vaccinium vitis-idaea*) in Scandinavia during the last century has been studied by several scholars, for instance Marianne Lien in Norway, and Nils-Arvid Bringéus (2000) in Sweden. All these studies discuss their topics in wider European contexts.

In 1927, Adam Maurizio in Lwów (Lviv) published his *Geschichte unserer Pflanzennahrung* “History of our food plants.” This study was an attempt to analyze a wild food plant from a wider Eurasian perspective and became one of the classics in its field. The gathering of foodstuffs from the wild has been an important issue for many ethnologists. Finnish ethnologist Ilmari Manninen (1894–1935) had published a comparative study on gathering wild plants in northern Eurasia already in 1931, and Hungarian ethnologist Béla Gunda (1911–1994) published another overview based on his own fieldwork in Central Europe (Gunda 1949).

An extensive study of the use of wild edible plants was launched in Poland in 1964–1969. It was carried out within a large project on material culture, and studied in a preselected grid of over 300 villages. The questionnaire concerned was over 100 pages long, which was the reason why it was often filled in hastily and superficially. Detailed questions about the use of certain species were included, for example, collecting spring sap from trees, and the gathering and consumption of fungi (Łuczaj 2010).

A five-volume work *Íslenskir sjávarhættir* “Icelandic sea-harvesting” (1980–1986), by Icelandic Lúðvík Kristjánsson (1911–2000), covers harvesting food and other utilities from the sea. A comparative work on the use of local food and emergency food in the circumpolar areas was published by Kerstin Eidlitz in 1969. Wild plants as food are still a popular topic for many ethnologists (Fenton 2000).

POPULAR MEDICINE

Studies of popular medicine among ethnologists are deeply related to ethnobiology. These studies began at the end of the nineteenth century, and developed during the twentieth century, for example, Ignacio María Barriola, Victor Lis Quibén and Ingrid Kuschick in Spain, Elfriede Grabner in Austria, Valer Butură in Romania, Ingjald Reichborn-Kjennerud in Norway, Justin Qvigstad in Sápmi, and R. K. Rasmussen in the Faroe Islands. Folk remedies and healing methods did not only include parts of plants and animals (cf. Honko 1982; Sõukand and Raal 2005). Most of these studies reflect a strong medico-historical and ethnological point of view and are mainly interested in the cultural and social aspects of folk culture. Some studies include minorities like the Roma (Tillhagen 1956). Only a few more recent studies provide proper identifications of the plants or animals involved (Muriel 2008; Allen and Hatfield 2004). Considerable numbers of written records on folk healers and popular remedies are to be found in, for instance, Danish, Estonian, Finnish, Hellenic, Icelandic, Irish, Lithuanian, Norwegian, Polish, Romanian, and Swedish folklore archives.

José María Palacín recorded a huge amount of data in Aragon for his dissertation in 1983 and demonstrates the richness of European popular knowledge. For example, he recorded 1500 remedies from one of his informants (coming from 29 different minerals, 31 animal, and 234 plant species) for healing some 203 illnesses. He needed 69 interviews with her, which were carried out over a period of six years. This work shows the huge amount of knowledge lost in the past decades. During Pardo-de-Santayana’s field studies

in Campoo, Spain (2005), he was commonly told that he should have asked their parents. Informants said that they knew practically nothing compared to their parents and grandparents. As an example, the informant who provided the most information in the ethnopharmacological survey included uses of 41 plants, three animals and four minerals for healing 30 human and animal illnesses (Pardo-de-Santayana 2008).

FOLKLORE AND PLANT NAME RESEARCH

Traditional plant names contain information about popular taxonomy, with plants arranged by color, features and other characteristics, as noted by the Danish philologist Marius Kristensen in 1911. Studies of plants in dialects have a long tradition in Europe. Local names are already to be found in plant lists from the 1600s and early 1700s, but it is also possible to study, for instance, Anglo Saxon and North Germanic plant names from the Viking age, with the help of rune stones, toponyms, and other sources. Nikolai I. Annenkov's (1819–1899) dictionary of plant names published in 1859 contains numerous Russian folk names and names in indigenous languages of northern and central Russia. In recent years, research on plant names has also begun to integrate the results of modern ethnobiology.

Heinrich Marzell (1885–1970) was the author of several hundred articles and about 20 books on *Volksbotanik*. His five volumes *Wörterbuch der deutschen Pflanzennamen* "Dictionary of German plant names" (1943–1979) represents the most important work on the subject published in any language. The folklore of plants had already become a research area in the mid-19th century. One of the most comprehensive works in the genre is Eugene Rolland's *Flore populaire* "Popular flora," published in 11 volumes (1896–1914).

There are many handbooks on the folklore and use of wild plants published in various European countries. Most of them are based on various written sources such as old herbals, travelogues, folklore records, and archaeological material. The application of source criticism is still nowhere near rigorous enough, and so we continue to find in publications much material taken from already published sources, rather than being based on local or specific knowledge. One good example is the information often given about the plant *Ranunculus scleratus*, used, it is said, by beggars to produce sores and ulcers, in order to excite pity and obtain gifts. No further contextual information is given. This is a 2000-year-old story taken from Apuleius Platonius, still presented in literature as being contemporary (cf. Svanberg 1998b).

Among more recent and more reliable volumes we can mention, for instance, Roy Vickery's *A Dictionary of Plant-Lore* (1995) on plant knowledge in Great Britain, and Tess Darwin's book on *The Scots Herbal* (1996) on Scottish plant lore. Vickery has also published a study of unlucky plants, on the basis of a survey conducted by the Folklore Society in London between 1982 and 1984 (Vickery 1985). The Belgian Marcel De Cleen and Maria Claire Lejeune's encyclopedia (2002–2004) is an impressive reference work which reviews ritual plants in central Europe. Pierre Lieutaghi is a French botanist who has analyzed plant use in Alpes-de-Haute-Provence (Lieutaghi 1983).

The Dane Vagn J. Brøndegaard has published countless studies in ethnobotany, based mainly on historical sources, and has gathered new material through interviews, not only in Denmark but also for instance in Spain (Brøndegaard 1985). Among his most important publications are his comparative studies of children's plant lore and use as toys and games. Brøndegaard has published several multi-volume handbooks on Danish ethnobotany and ethnozoology in the 1980s and 1990s.

BOTANISTS ON PLANT USE

Some botanists, including a few amateurs, have undertaken ethnobotanical fieldwork of interest in Europe. In 1900 the first botanist to publish a proper ethnobotanical work in Italy, Giovanni Pons, wrote an article on the folk botany of the Waldensian Alpine valleys in Northwestern Italy. Once again details about methodology, such as sampling, number of interviewees, and adopted field techniques were not reported, but the approach of Pons' research was surely interdisciplinary: the authors reported linguistic labels of folk taxa, their local uses, and botanical voucher specimens were apparently collected. A more economic–botanical perspective was taken by the medical doctor and botanist Oreste Mattiolo (1856–1947), who in 1919 wrote the first food ethnobotanical survey in Italy, a review on wild food plant uses in Piedmont.

Danish dendrologist Axel Lange's (1871–1941) booklets from the 1930s, discussing local plant use on Danish islands, qualify as pioneering ethnobotanical works in Scandinavia. Also in Norway, several botanists performed ethnobotanical studies, that is, Jens Holmboe (1880–1943) and Rolf Nordhagen (1894–1979). From Sweden we can mention Gösta Ilien's exemplary thorough and methodological field study of butterbur (*Petasites hybridus*) and its role for the peasants as veterinary medicine, published in 1945. Lisa Johansson (1894–1982) gathered information on plant use in the mid-1940s among crofters in northern Sweden, especially as dyes (over 400 recipes), medicine, and for technical purposes, completed with voucher specimens.

In Romania, Alexandru Borza (1887–1971), who spent a lifetime studying the use of plants, published a comprehensive handbook of traditional plant knowledge that covers not only Romania, but also Moldavia, Bulgaria, and adjacent areas in the Balkan Peninsula (Borza 1968).

In Italy, proper systematic ethnobotanical studies began after World War II. They were initiated by scholars at the Department of Botany of the University of Genoa, at that time the lynch-pin of ethnomedical studies in Europe, with the beginning of Antonio Scarpa's research team. The first Italian ethnobotanical studies come from this research group. For instance, Elsa Bertagnon (1955) and Albarosa Bandini (1961) investigated the use of medicinal plants in the mountainous regions of Eastern Liguria, and Caterina Chioyenda-Bensi (1957) did field ethnobotanical research in Walser communities in Piedmont.

From the 1960s onwards, more and more ethnobotanical studies were conducted within a number of botanical institutes at Italian universities (especially in Genoa, Padua, Pisa, Florence, and Rome), generally carried out by medical botanists at pharmacy schools. Ethnobotany has for many decades been a subject area officially classified by the Italian Ministry of Research as part of the broader medical botany/pharmacognosy area.

Between 1925 and 1973, botanist Ove Arbo Høeg (1898–1993) gathered an enormous amount of field material from all over Norway, published in 1974 in his *Planter og tradisjon* "Plants and tradition." He has published many articles on plant use—for instance on children's games—and also a monograph on the juniper (*Juniperus communis*) in Norwegian folk tradition in 1981. This monograph was published by the Norwegian Forestry Museum as the first volume in a series on the cultural history of Norwegian trees. A successor of Høeg is Torbjørn Alm at Tromsø Museum. He has published monographs on various plant taxa, based on interviews made with Kven, Norwegian, and Saami informants of North Norway (Alm 2002).

Gustav Vilbaste's (1885–1967) rich plant name material with many notes on folk botany from Estonia is worth mentioning (Vilbaste 1993). He is, with his many publications and a large collection of records, considered the founder of ethnobotany in Estonia.

Jerzy Wojciech Szulczewski (1879–1969) contributed immensely to the ethnobiology of western Poland. Trained as a biologist, he gathered valuable, detailed, and reliable material about medicinal plants, and folk beliefs about plants and edible mushrooms. He was a pioneer in the field of market surveys. One of his achievements is a detailed record of plants and mushrooms sold in the market of Poznań, where he lists as many as 50 taxa sold there. At the end of the twentieth century, Piotr Köhler published excellent studies on the history of Polish ethnobotany, rediscovering Rostafiński's and Udziela's works (Köhler 1996).

BOX 12.3 *Traditional Toys*

Studies of material culture give a good opportunity of understanding how locally available biological resources could be used. Almost every part of an animal was utilized in pre-industrial Europe. On the Faroes, pilot whales have provided a lot of benefits like food, fat, fuel, construction material, and tools for the inhabitants.

As elsewhere, the children on the islands used locally available material to create their own toys. The thin tendon discs of bone that lie between the vertebrae in the region of the tail of the pilot whale were used to make whirling discs. Ethnographer Nelson Annandale observed this during his visit to

the Faroes at the beginning of the twentieth century. He describes how they made a whirling disc by threading the thin tendon disc “upon a loop of wool or string. The ends of the loop are held, as wide apart as possible, in the two hands, and it is caused to rotate in such a way that it becomes completely twisted, the discs then revolve rapidly, producing a humming sound, if the hands be alternately approached to and drawn apart from another.”

Nowadays, the Faroe islanders only use the meat and blubber of the whale. However, these kinds of whirling discs are sometimes still made in the Faroes.



Figure 12.6 Faroes whirling disc (*snurra*) made of a tendon disc from a pilot whale. Photograph courtesy of Ingvar Svanberg.

Spanish botanist Pio Font Quer (1888–1964) is the author of one of the most influential works about Iberian medicinal plants, *Plantas medicinales* “Medicinal Plants” from 1961. His book consists of a very interesting introduction and monographs of medicinal plants. Each monograph includes a critical review of the plant’s medicinal uses. Although he never used the term ethnobotany, he has inspired modern ethnobotanists, and he has been considered the father of this discipline in Spain.

ENCOUNTERS BETWEEN HUMAN AND NONHUMAN ANIMALS

As in ethnobotany, most research in ethnozoology has been carried out within the framework of ethnology. When Faroese ethnographer Robert Joensen (1912–1997) realized that his fellow islanders had an extraordinary store of knowledge of things “they had learned through their daily work on the land, in the mountains and the sea,” he started to make a comprehensive record of all they knew about fishing, hunting, and animal husbandry, resulting in several books. Interesting studies on the relationship between animals and rural people have been conducted by the above-mentioned Hungarian ethnologist Béla Gunda, who has published detailed studies on such diverse topics as taming cranes among peasants in Central Europe, gathering of eggs of waterfowl in Hungary, traps and trapping in the Carpatho-Balkan area and the use of fish poisons in the Balkan Peninsula—all excellent works (Gunda 1979). Nils Storå is another researcher discussing the ethnoecological and ethnozoological aspects of peasant life in the Finnish archipelago (e.g., Storå 1985). Mart Mäger (1935–1993) gathered a rich body of material based on fieldwork on Estonian folk ornithology, which was only partly used in his *Eesti linnunimetused* “Estonian bird names” (1967).

Scottish ethnologist Alexander Fenton has made detailed research on the way of life among islanders in Orkney and Shetland. His many studies, collected in *The Northern Isles* (1997), give a good insight into how dependent on local biological resources the islanders were in former times. Other studies include fowling and egg gathering (Berg 1980; Nørrevang 1986) and traditional whaling in the Faroes (Joensen 2009). Patricia Lysaght has published excellent studies on food provision on Great Blasket Island on the Irish west coast (Lysaght 2001). Popular hunting is another topic of interest for ethnobiologists. Howe (1981) provides a sophisticated theoretical study on traditional fox hunting in the English countryside.

Researchers in ethnobiology seldom pay attention to invertebrates (cf. Svanberg 2009). However, Norwegian linguist Geir Wiggen recently published an interesting study on traditional names of lower animals (Wiggen 2008).

TOWARDS A SCIENCE OF ETHNOBIOLOGY IN EUROPE SINCE 1980

Although ethnobotany has existed for over a century as a named research field in North America, it was not until the 1980s that ethnobiology and ethnobotany emerged as independent academic disciplines in Europe. Many European scholars still dwell within disciplines like anthropology, botany, and ecology, but ethnobiology has grown rapidly over the last 15–20 years. An increasing number of scholars view ethnobiology as a separate discipline with its own methods and theories, not only as a hard-to-define multidisciplinary field. In Europe, an abundance of courses, seminars, and annual conferences are now available,

especially in Great Britain, Italy, and Spain. One of the largest ethnobotanical libraries in the world, V.J. Brøndegaard's collection, is now available to scholars at the Royal Swedish Academy of Agriculture and Forestry in Stockholm.

Ethnobiology in Europe has built further on the extensive research which has already been carried out in a number of other fields (botany, ethnology, folklore, ecology, human geography, linguistics, and zoology). The first review covering all Italian ethnobotanical studies until 2004 has been recently compiled by Paolo Maria Guarrera, ethnobotanist at the National Folkloric Museum of Rome. This review considers hundreds of primary folkloric and ethnobotanical literature and field studies carried out in the last century in Italy (Guarrera 2006), and followed an impressive review of Sardinian ethnobotanical data (Atzei 2003). A full ethnobotanical bibliography of Polish ethnographic literature (nearly 400 articles and books) between 1876 and 2005 (Klepacki 2007), and a review of recent ethnobotanical studies in Spain were recently published (Morales et al. 2011).

CURRENT TRENDS

Ethnobiologists in Europe should continue to systematize the large body of data collected in the last century by ethnographers and linguists (Babulka 1996; Łuczaj and Szymański 2007). We need more monographs like Nadiya Varhol's interesting and uniquely detailed study of plants in the culture of the Carpatho-Rusyn minority in Slovakia published in 2002. Few studies compare in detail the materials gathered in neighboring countries (Ståhlberg and Svanberg 2006; Svanberg 2007b). Some focus has been given on gender perspectives on folkbiological knowledge (Pieroni 2003). Analysis of material culture is an important issue (Svanberg 1998a). Dendrochronology is also an important method for ethnobiologists (cf. Niklasson et al. 1999). Technical analyses of textiles, tools, and furniture is useful for ethnobiologists (cf. Cybulska et al. 2008). Plant monographs continue to be important (Svanberg 1997; Molina et al. 2009; Vallès et al. 2004). Many contemporary Russian scholars do their ethnobotanical studies within linguistics, for instance Nadezhda Konovalova (2001), who has researched historical Russian plant names, Julia Koppaleva (2007), who has studying the naming of plants in Karelia, and Valeria Kolosova, who in 2003 published a study comparing Slavonic plant names and folklore related to plants.

A priority is recording unknown traditions of local animal and plant knowledge in rural areas. Fieldwork is still possible, especially in eastern and southern Europe, with recent publications from Albania, Bosnia-Herzegovina, Bulgaria, Greece, Italy, Ireland, Serbia, Spain, and Portugal (e.g., Camejo-Rodrigues et al. 2003; Dolan 2007; Guarrera et al. 2006; Hanlidou et al. 2004; Ivancheva and Stantcheva 2000; Jaric et al. 2007; Redzic 2006).

A few larger international projects have recently been carried out in Europe. *Flora Celtica* is based at the Royal Botanic Garden in Edinburgh, and is documenting the knowledge and sustainable use of native plants in the Celtic regions of Europe. The project has focused on the use of native plants in Scotland (Miliken and Bridgewater 2004).

The European Commission has so far funded only one large collaborative ethnobiological project in Europe (RUBIA 2003–2006), which was focused on the evaluation and comparative analysis of ethnobotanical knowledge as cultural heritage in 12 selected southern European and Mediterranean areas (González-Tejero et al. 2008; Hadjichambis et al. 2008; Pieroni et al. 2006), while in another funded collaborative project ethnobotany represented a minor part within a main bioprospecting framework for researching new nutraceuticals (Heinrich et al. 2006; Rivera et al. 2005).



Figure 12.7 The regal fern, *Osmunda regalis*, is still a popular domestic medicine in Asturias and Cantabria, Spain. (a) Shows the gathered rhizomes of the fern; and (b) a bottle of *Antojil* wine made of the rhizomes macerated in white wine. Photograph courtesy of Manuel Pardo-de-Santayana. (See color insert.)

Ian Majnep and Ralph Bulmer's *Birds of My Kalam Country* (1977; see Hunn this volume) is now a minor classic in ethnobiology, and has been called the first postmodern writing on the subject. Bulmer himself referred to the cooperation between the Danish ethnographer Emelie Demant-Hatt, and reindeer-herding Johan Turi's book from 1910 that had obviously inspired him (Marcus 1991). An author working in the same tradition is Yngve Ryd (2005) who, in cooperation with elderly native Saami consultants, has produced several in-depth studies of ancient knowledge of snow, fire, and predators. By spending many years with his Saami consultants, Ryd obtained details concerning the Saami landscape like no other before. This method of intensive work with a few well informed native consultants will probably be more common in the future, as we try to save old knowledge among rural people in Europe.

We have also seen an increasing number of studies on local ecological knowledge in various settings of Europe (Molnar et al. 2008; Ruotsala 1999; Svanberg 2005). In a series of works attracting international attention, leading European system ecologists have analyzed those insights regarding the ecosystem—its function and vulnerability—which are embodied in folk knowledge (Colding and Folke 2002).

Traditional homegardens are to be found in mountainous areas in various parts of Europe and we have seen several ethnobiological publications over the last few years

(Agelet et al. 2000; Reyes-García et al. 2010; Szabó et al. 2002; Vogl-Lukasser and Vogl 2001). Homegardens have a multiplicity of functions and are a repository of a diversity of species and cultivars. Gardens with *Angelica archangelica* can still be found in the Faroe Islands, Iceland, and Norway, almost as they were during the Viking age. An old strain of a sweeter kind of cultivated angelica still exists in Norway (Fosså 2006).

Ethnomycological studies have so far been very rarely conducted in Europe, apart from Poland (e.g., Szulczewski 1996). Some works have partially addressed this issue within more general food ethnobotanical field studies (i.e., Pieroni et al. 2005) or ethnolinguistics (Bartnicka-Dąbkowska 1964). However, a first purely ethnomycological research project has recently been completed in Italy (Camangi et al. 2008).

Ethnoveterinary practice is another field attracting contemporary scholars, especially in Southern Europe (Blanco et al. 1999; Bonet and Vallès 2006; Bullitta et al. 2007; Pieroni et al. 2006; Uncini Manganelli et al. 2001). Recent field studies have shifted from listing local veterinary uses of medicinal plants to including local knowledge of plants important in peasants' communities for improving the quality of meat and dairy products (Pieroni et al. 2004). An overall ethnoveterinary checklist devoted to veterinarians has been recently implemented in Italy by reviewing more than 100 folkloric and ethnobotanical fieldworks conducted in Italy during the second half of the twentieth century (Viegi et al. 2003). On the other hand, ethnoveterinary studies in Scandinavia have taken a more historical perspective (Brag and Hansen 1994; Waller et al. 2001).

Recently, studies of perceptions and uses of plants among migrant communities have emerged (Ceuterick et al. 2008; Pieroni and Gray 2008; Pieroni et al. 2007; Sandhu and Heinrich 2005; Van An del and Westers 2010).



Figure 12.8 Traditional *Angelica* garden in the village Gjógv, Faroe Islands. Photograph courtesy of Ingvar Svanberg.

There are neglected fields also within European ethnobiology. The importance of animal and plant knowledge among children deserves more attention (Łuczaj 2008, 2009). Child culture relating to plants and animals very seldom carries over into adulthood, and has therefore remained unnoticed by scholars. As Myrdene Anderson (2000) has shown, children's beliefs and practices sometimes contain "survivals" of older plant knowledge.

There are some recent historically oriented studies on the link between animals and humans, but the field deserves more attention (Chevallier et al. 1988; Svanberg 2001a, 2006, 2007a; Svanberg and Ægisson 2006). Ethnoentomology is rare, but a recent study describes how Carntian children used to eat the sweet crop from moths of the genus *Zygaena* (Zagrobely et al. 2009). Traditional knowledge about predators has been documented among reindeer herdsman. Fish management is another important issue (Eythorsson 1993). Perhaps Ragnar Kinzelbach's (1999) cultural zoology approach can inspire more theoretically sophisticated studies within the field of ethnozoology in Europe. Keeping pets has a very long tradition in Europe. Not only dogs and cats, but numerous other species, have been used as companion animals. The relationship people have with these animals is another neglected topic for European ethnobiologists.

REFERENCES

- AGELET A, VALLÈS J. Studies on pharmaceutical ethnobotany in the region of Pallars (Pyrenees, Catalonia, Iberian Peninsula): general results and new or very rare medicinal plants. *J Ethnopharmacol* 2001;77:57–70.
- ALLEN DE, HATFIELD G. Medicinal plants in folk tradition: an ethnobotany of Britain and Ireland. Cambridge: Timber Press; 2004.
- ALM T. Norwegian and Sámi ethnobotany of *Veratrum album* (Melanthiaceae). *Sida* 2002;20:611–619.
- ANDERSON M. Sami children and traditional knowledge. In: SVANBERG I, TUNÓN H, editors. Ecological knowledge in the north: studies in ethnobiology. Uppsala: Swedish Science Press; 2000. p 55–65.
- ATZEI AD. Le piante nella tradizione popolare della Sardegna. Sassari: Delfino Editore; 2003.
- BABULKA P. Evaluation of medicinal plants used in Hungarian ethnomedicine, with special reference to the medicinally used food plants. In: SCHRÖDER E, BALANSARD G, CABALION P, et al., editors. Médicaments et aliments: approche ethnopharmacologique. Paris: Orstrom; 1996. p 129–139.
- BALICK MJ, COX PA. Plants, people, and culture: the science of ethnobotany. New York: Scientific American Library; 1996.
- BANDINI A. Le piante della medicina tradizionale nell'alta Val di Vara (*Liguria orientale*). *Webbia* 1961;16:143–163.
- BARRAU J. L'ethnobotanique au carrefour des sciences naturelles et des sciences humaines. *Bull Soc Bot France* 1971;118:237–248.
- BARTNICKA-DĄBKOWSKA B. Polskie ludowe nazwy grzybów. *Prace Językoz* 1964;42:1–142.
- BERG G. The collection of wild birds' eggs and nestlings in Sweden. *Fróðskaparrit. Ann Soc Sci Færoensis* 1980;28–29:132–157.
- BERTAGNON E. Sulla flora medicinale della Liguria. Usi tradizionali dell'Alta Fontanabuona. *Atti Accad Lig Sci Lett* 1955;11:201–214.
- BLANCO E, MACÍA MJ, MORALES R. Medicinal and veterinary plants of El Caurel (Galicia, northwest Spain). *J Ethnopharmacol* 1999;65:113–124.
- BONET MA, VALLÈS J. Ethnobotany of Montseny biosphere reserve (Catalonia, Iberian Peninsula): plants used in veterinary medicine. *J Ethnopharmacol* 2006;110:130–147.
- BORZA A. Notițe etnobotanice. *Bul Grădinii Bot Cluj* 1931; 11:51–52.
- BORZA A. Dicționar etnobotanic cuprinzând denumirile populare românești și în alte limbi ale plantelor din România. București: Editura Academiei Republicii Socialiste România; 1968.
- BRAG S, HANSEN H-J. Treatment of ruminal indigestion according to popular beliefs in Sweden. *Rev Sci Tech Off Int Epizoot* 1994;13:529–535.
- BRINGÉUS N-A. The red gold of the forest. In: LYSAGHT P, editor. Food from nature: attitudes, strategies and culinary practices. Uppsala: Academiae Regiae Gustavi Adolphi; 2000. p 225–239.
- BRONDEGAARD VJ. Ethnobotanik. Pflanzen im Brauchtum, in der Geschichte und Volkzmedizin. Hamburg: Mensch und Leben; 1985.
- BULLITTA S, PILUZZA G, VIEGI L. Plant resources used for traditional ethnoveterinary phytotherapy in Sardinia (Italy). *Genet Resour Crop Ev* 2007;54:1447–1464.
- CAMANGI F, STEFANI A, SEBASTIANI L, et al. Etnomedicologia. La risorsa fungo in Alta Valle del Vara. La Spezia: CM Alta Valle del Vara e SSSA; 2008.
- CAMEJO-RODRIGUES J, ASCENSAO L, BONET MA, VALLÈS J. An ethnobotanical study of medicinal and aromatic plants in

- the Natural Park of “Serra de Sao Mamede” (Portugal). *J Ethnopharmacol* 2003;89:199–209.
- CEUTERICK M, VANDEBROEK I, TORRY B, PIERONI A. Cross-cultural adaptation in urban ethnobotany: the Columbian folk pharmacopoeia in London. *J Ethnopharmacol* 2008; 120:342–359.
- CHEVALLIER D, LANGLOIS C, PUJOL R. A propos d’ethnozoologie. *Terrain* 1988;10:108–111.
- CHIOVENDA-BENSI C. Tradizioni ed usi fitoterapici popolari. La Valsesia. *Atti Accad Lig Sci Lett* 1957;13:190–205.
- CLÉMENT D. The historical foundations of ethnobiology (1860–1899). *J Ethnobiol* 1998;18:161–187.
- COLDING J, FOLKE C. Social taboos: invisible systems of local resource management and biodiversity conservation. *Ecol Appl* 2001;11:584–600.
- COTTON CM. *Ethnobotany: principles and applications*. Chichester: John Wiley and Sons; 1996.
- COX PA. Carl Linnaeus: the roots of ethnobotany. *Odyssey* 2001;10(2):6–8.
- CYBULSKA M, JEDRASZEK-BOMBA A, KUBERSKI S, WRZOSEK H. Methods of chemical and physicochemical analysis in the identification of archaeological and historical textiles. *Fibres Text East Eur* 2008;16(5):67–73.
- DAVIS WE. Ethnobotany: an old practice, a new discipline. In: SCHULTEZ RE, VON REIS S, editors. *Ethnobotany: evolution of a discipline*. London: Chapman and Hall; 1995. p 40–51.
- DE CLEENE M, LEJEUNE MC. *Compendium of ritual plants in Europe*. Volumes 1–2. Ghent: Man and Culture; 2002–2004.
- DOLAN JM. Ochrinil’s legacy: Irish women’s knowledge of medicinal plants. *Harvard Pap Bot* 2007;12(2): 369–386.
- EIDLITZ K. *Food and emergency food in the circumpolar areas*. Uppsala: Almqvist & Wiksell International; 1969.
- EYTHORSSON E. Sami Fjord fishermen and the state: traditional knowledge and resource management in northern Norway. In: INGLIS J, editor. *Traditional ecological knowledge: concepts and cases*. Ottawa: International Development Research Centre; 1993. p 133–142.
- FENTON A. Wild plants and hungry time. In: LYSAGHT P, editor. *Food from nature: attitudes, strategies and culinary practices*. Uppsala: Academiae Regiae Gustavi Adolphi; 2000. p 182–194.
- FERRARO G. *Botanica popolare di Carpeneto d’Acqui, provincia d’Alessandria*. *Archivio per lo Studio delle Tradizioni Popolari*, 1884–1885;3:596–604; 4:129–137, 165–189, 405–420.
- FJELLSTRÖM P. *Angelica archangelica* in the diet of the Lapps and the Nordic peoples. In: FURMARK A, editor. *Lapponica*. Uppsala: Almqvist and Wiksell International; 1964. p 99–115.
- FORD RI. *Ethnobotany: historical diversity and synthesis*. In: FORD RI, editor. *The nature and status of ethnobotany*. Ann Arbor (MI): Museum of Anthropology Publications; 1978. p 33–49.
- FOSSÅ O. *Angelica*: from Norwegian mountains to the English trifle. In: HOSKING R, editor. *Wild food: proceedings of the Oxford Symposium on Food and Cookery* 2004. Totnes: Prospect Books; 2006. p 131–142.
- GLÜCK L. *Skizzen aus der Volksmedizin und dem medicinischen Aberglauben in Bosnien und der Hercegovina*. *Wissensch Mitt Bosnien Hercegov* 1894;2:392–454.
- GONZÁLEZ-TEJERO M, CASARES-PORCEL M, SÁNCHEZ-ROJAS CP, et al. Medicinal plants in the Mediterranean area: synthesis of the results of the project Rubia. *J Ethnopharmacol* 2008; 116:341–357.
- GRYNAEUS T. ‘Ear-herb’ (*Sempervivum tectorum* L.) in Hungarian ethnomedicine. *Acta Ethnograph Hung* 2001; 46:261–271.
- GUARRERA PM. *Usi e tradizioni della flora italiana*. *Medicinapopolare ed etnobotanica*. Rome: Aracne Editrice; 2006.
- GUARRERA PM, SALERNO G, CANEVA G. Food, flavouring and feed plant traditions in the Tyrrhenian sector of Basilicata, Italy. *J Ethnobiol Ethnomed* 2006;2:37.
- GUDMUNDSSON G. Gathering and processing of lyme-grass (*Elymus arenarius* L.) in Iceland. *Veg Hist Archeobot* 1996;5:213–223.
- GUNDA B. Plant gathering in the economic life of Eurasia. *Southwest J Anthropol* 1949;5:369–378.
- GUNDA B. *Ethnographica Carpatho-Balcanica*. Budapest: Akadémiai Kiadó; 1979.
- HADJICHAMBIS A, PARASKEVA-HADJICHAMBI D, DELLA A, et al. Wild and semi-domesticated food plants consumption in seven circum-Mediterranean areas. *Int J Food Sci Nutr* 2008;59:383–414.
- HANLIDOU E, KAROUSOU R, KLEFTOYANNI V, KOKKINI S. The herbal market of Thessaloniki (N Greece) and its relation to the ethnobotanical tradition. *J Ethnopharmacol* 2004; 91:281–299.
- HAUDRICOURT A-G. Une discipline nouvelle: l’ethnobotanique. *Cahiers Rational* 1956;158:293–294.
- HEINRICH M, NEBEL S, LEONTI M, et al. Local food—nutraceuticals’ bridging the gap between local knowledge and global needs. *Forum Nutr* 2006;59:1–17.
- HOLMSTEDT BR. Historical perspectives and future of ethnopharmacology. In: SCHULTEZ RE, VON REIS S. *Ethnobotany: evolution of a discipline*. London: Chapman and Hall; 1995. p 320–338.
- HONKO L. Folk medicine and health care systems. *Arv* 1982; 38:57–86.
- HOWE J. Fox hunting as ritual. *Am Ethnol* 1981;8:278–300.
- HUNN E. Ethnobiology in four phases. *J Ethnobiol* 2007; 27:1–10.
- ILJEN G. Förekomsten av *Petasites hybridus* i Skåne. *Bot Notiser* 1945;3:182–303.
- IVANCHEVA S, STANTCHEVA B. Ethnobotanical inventory of medicinal plants in Bulgaria. *J Ethnopharmacol* 2000; 69:165–172.
- JARIC S, POPOVIC Z, MACUKANOVIC-JOCIC M, et al. An ethnobotanical study on the usage of wild medicinal herbs from Kopaonik Mountain (Central Serbia). *J Ethnopharmacol* 2007;111:160–175.
- JOENSEN R. *Fåreavl på Færøerne*. København: Reitzel; 1979.

- JOENSEN JP. Pilot whaling in the Faroe Islands. History—ethnography—symbols. Tórshavn: Faroese University Press; 2009.
- KINZELBACH R. Was ist Kulturzoologie? Paradigmen zur Koevolution von Mensch und Tier. Beitr Archäozool Prähist Anthropol 1999;2:11–20.
- KINZELBACH R. The distribution of the serin (*Serinus serinus* L. 1766) in the 16th century. J Ornithol 2004;145: 177–187.
- KLEPACKI P. Etnobotanika w Polsce: przeszłość i terażniejszość. Analecta 2007;16:191–245.
- KÖHLER P. Zielnik Seweryna Udzieli: dokumentacja pracy “Rośliny w wierzeniach ludu krakowskiego”. Lud 1996; 80:179–186.
- KOLOSOVA VD. Лексика и символика народной ботаники восточных славян (на общеславянском фоне). Этнолингвистический аспект. Москва: наук; 2003.
- KONOVALOVA NI. Народная фитонимия как фрагмент языковой картины мира. Екатеринбург: Изд-во Дома учителя; 2001.
- KOPPALEVA J. Финская народная лексика флоры (становление и функционирование). Petrosavodsk. КарНЦ РАН; 2007.
- KOWALSKA-LEWICKA A. Etnobotanika. Etnograf Polska 1964; 8:207–214.
- KRISTENSEN M. Folkelige planteslægter In: Fästskrift till H.F. Feilberg från nordiska språk- och folklivsforskare på 80-års-dagen den 6 augusti 1911. Uppsala: Norstedt; 1911. p 41–57.
- LÉVI-STRAUSS C. La pensée sauvage. Paris: Plon; 1962.
- LIEUTAGHI P. L’ethnobotanique au péril du gazon. Terrain 1983;1:4–10.
- ŁUCZAJ Ł. Archival data on wild food plants eaten in Poland in 1948. J Ethnobiol Ethnomed 2008;4:4.
- ŁUCZAJ Ł. Primroses versus spruces: cultural differences between flora depicted in British and Polish children’s books. Ethnobot Res Appl 2009;7:115–121.
- ŁUCZAJ Ł. Changes in the utilization of wild green vegetables in Poland since the 19th century: a comparison of four ethnobotanical surveys. J Ethnopharmacol 2010;127: 395–404.
- ŁUCZAJ Ł, SZYMAŃSKI W. Wild vascular plants gathered for consumption in the Polish countryside: a review. J Ethnobiol Ethnomed 2007;3:17.
- LYSAGHT P. Food-provision strategies on the Great Blasket Island: strand and shore In: Ó CATHÁIN S, editor. Northern Lights: following folklore in North-Western Europe. Dublin: University College Dublin Press; 2001. p 141–148.
- MÄGER M. Eesti linnunimetused. Tallinn: Eesti NSV Teaduste Akadeemia; 1967.
- MANNINEN I. Überreste der Sammlerstufe und Notnahrung aus dem Pflanzenreich bei den nordeurasischen, vorzugsweise den finnischen Völkern. Eurasia Septentr Antiq 1931; 6:30–48.
- MARCUS GE. Notes and quotes concerning the further collaboration of Ian Saem Majne and Ralph Bulmer. In: PAWLEY A, editor. Man and a half: essays in Pacific anthropology and ethnobiology in honour of Ralph Bulmer. Auckland: Polynesian Society; 1991. p 37–45.
- MATTIROLO O. I vegetali alimentari spontanei del Piemonte (Phytoalimurgia Pedemontana). Torino: S. Lattes; 1919.
- MILLIKEN W, BRIDGEWATER S. Flora celtica: plants and people in Scotland. Edinburgh: Royal Botanical Garden; 2004.
- MORALES R, TARDÍO J, ACEITUNO L, MOLINA M, PARDO-DE-SANTAYANA. Biodiversity and Ethnobotany in Spain. Memorias R. Soc. Esp. Hist. Nat., 2^a ép. 2011; 91–144.
- MOLINA M, REYES-GARCÍA M, PARDO-DE-SANTAYANA M. Local knowledge and management of the royal fern (*Osmunda regalis* L.) in northern Spain: implications for biodiversity conservation. Amer Fern J 2009;99:45–55.
- MOLNÁR Z, BARTHA S, BABAI D. Traditional ecological knowledge as a concept and data source for historical ecology, vegetation science and conservation biology: a Hungarian perspective. In: Szabó P, HÉDL R, editors. Human nature: studies in historical ecology and environmental history. Brno: Institute of Botany of the ASCR; 2008. p 14–27.
- MOLONEY MF. Irish ethno-botany and the evolution of medicine in Ireland. Dublin: M.H. Gill; 1919.
- MURIEL MP. La medicina popular en la provincia de Palencia. Palencia: Institución Tello Téllez de Meneses y Diputación Provincial de Palencia; 2008.
- NELSON MC, SVANBERG I. Lichens as food: historical perspectives on food propaganda. Svenska Linnésällskapetets Årsskrift 1987;1986–1987:7–51.
- NIKLISSON M, ZACKRISSON O, ÖSTLUND L. A dendroecological reconstruction of use by Saami of Scots pine (*Pinus sylvestris* L.) inner bark over the last 350 years at Sädvajaure, N. Sweden. Veg Hist Archaeobot 1994;3: 183–190.
- NORDENSKIÖLD E. Om insamlandet af etnografiska föremål. Ymer 1908;27:86–93.
- NØRREVANG A. Traditions of sea bird fowling in the Faroes: an ecological basis for sustained fowling. Ornis Scand 1986;17:275–281.
- PALACÍN JM. Las plantas en la medicina popular del Alto Aragón. Navarra: Faculty of Pharmacy, University of Navarra; 1983.
- PARDO-DE-SANTAYANA M. Estudios etnobotánicos en Campoo (Cantabria). Conocimiento y uso tradicional sobre plantas. Madrid: CSIC; 2008.
- PARDO-DE-SANTAYANA M, MORALES R. Chamomiles in Spain. The dynamics of plant nomenclature. In: PARDO DE SANTAYANA M, PIERONI A, PURI R, editors. Ethnobotany in the new Europe: people, health and wild plant resources. New York, Oxford, UK: Berghahn Press; 2010. p 283–307.
- PARDO-DE-SANTAYANA M, TARDÍO J, MORALES R. The gathering and consumption of wild edible plants in Campoo (Cantabria, Spain). Int J Food Sci Nutr 2005;56:529–542.
- PARDO-DE-SANTAYANA M, TARDÍO J, BLANCO E, et al. Traditional knowledge of wild edible plants used in the northwest of the Iberian Peninsula (Spain and Portugal). J Ethnobiol Ethnomed 2007;3:27.

- PARDO-DE-SANTAYANA M, PIERONI A, PURI RK. The ethnobotany of Europe, past and present. In: PARDO-DE-SANTAYANA MA, PIERONI A, PURI R. Ethnobotany in the new Europe: people, health and plant resources. Oxford: Berghahn Press; 2010. p 1–15.
- PIERONI A. Wild food plants and Arbëresh women in Lucania, southern Italy. In: HOWARD PL, editor. Women and plants: gender relations in biodiversity management and conservation. London: Zed Books; 2003. p 66–82.
- PIERONI A, GRAY C. Herbal and food folk medicines of the Russlanddeutschen living in Künzelsau/Taläcker, South-western Germany. *Phytother Res* 2008;22:889–901.
- PIERONI A, GUSTI ME, DE PASQUALE, et al. Circum-Mediterranean cultural heritage and medicinal plant uses in traditional animal healthcare: a field survey in eight selected areas within the RUBIA project. *J Ethnobiol Ethnom* 2006;2:16.
- PIERONI A, HOULIHAN L, ANSARI N, et al. Medicinal perceptions of vegetables traditionally consumed by South-Asian migrants living in Bradford, Northern England. *J Ethnopharmacol* 2007;113:100–110.
- PIERONI A, NEBEL S, SANTORO RF, HEINRICH M. Food for two seasons: culinary uses of non-cultivated local vegetables and mushrooms in a south Italian village. *Int J Food Sci Nutr* 2005;56:245–272.
- PIERONI A, QUAVE CL, SANTORO RF. Folk pharmaceutical knowledge in the territory of the Dolomiti Lucane, inland southern Italy. *J Ethnopharmacol* 2004;95:373–384.
- PIETRÈ G. *Medicina popolare siciliana*. Torino: Clausen; 1896.
- PONS G. Primo contributo alla flora popolare Valdese. *Boll Soc Bot Ital* 1900;101–108:216–222.
- RASMUSSEN H. Grüne Kränzchen: die dänische Tradition des Waldmeisters (*Asperula odorata*). *Ethnol Scand* 1975;5:92–110.
- RAVEN JE. Plants and plant lore in ancient Greece. Oxford: Leopard's Head Press; 2000.
- REDZIC S. Wild edible plants and their traditional use in the human nutrition in Bosnia-Herzegovina. *Ecol Food Nutr* 2006;45:189–232.
- REYES-GARCÍA V, VILA S, ACEITUNO L, CALVET-MIR L, GARNATJE T, JESCH A, LASTRA JJ, PARADA M, RIGAT M, VALLÈS J, PARDO-DE-SANTAYANA M. Gendered Home Gardens. A study in three mountain areas of the Iberian Peninsula. *Econ Botany* 2010;46(3):235–247.
- RIVERA D, OBON C, INOCENCIO C, HEINRICH M, VERDE A, et al. The ethnobotanical study of local Mediterranean food plants as medicinal resources in southern Spain. *J Pharmacol Physiol* 2005;56(Suppl 1):97–114.
- RUOTSALA H. The reindeer herder's environment. In: MÜLLER-WILLE L, editor. Human environmental interactions: issues and concerns in Upper Lapland, Finland. Rovaniemi: Arctic Centre; 1999. p 41–47.
- RYD Y. Eld: flammor och glöd: samisk eldkonst. Stockholm: Natur och kultur; 2005.
- SANDHU DS, HEINRICH M. The use of health foods, spices and other botanicals in the Sikh community in London. *Phytother Res* 2005;19:633–642.
- SANTESSON CG. Einiges über die giftige Fuchs- oder Wolfsflechte (*Letharia vulpina* (L.) Vain.), in Festschrift tillägnad Professor Gustaf Fr. Göthlin. Uppsala: Almqvist & Wiksell; 1939. p 1–8.
- SOBOTKA P. Rostlinstvo a jeho význam v národních písničkách, pověstech, bájích, obřadech a pověrách slovanských. Praha: Maticе české; 1879.
- SÖUKAND R, RAAL A. Data on medicinal plants in Estonian folk medicine: collection, formation and overview of previous research. *Folklore: Electr J Folkl* 2005;30:171–198.
- STORÅ N. Adaptive dynamics and island life: resource use in the Åland Islands. *Stud Fennica* 1985;30:113–144.
- STÄHLBERG S, SVANBERG I. Sarana in Eurasian folk botany. *J Soc Finno-Ougrienne* 2006;91:133–157.
- SVANBERG I. Turkic ethnobotany and ethnozoology as recorded by Johan Peter Falck. *Sven Linnésällsk Årsskr* 1987;53–118.
- SVANBERG I. Field horsetail (*Equisetum arvense*) as a food plant. *Fröðskaparrit: Ann Soc Sci Færoensis* 1997;45:45–55.
- SVANBERG I. The use of rush (*Juncus*) and cottongrass (*Eriophorum*) as wicks: an ethnobotanical background to a Faroese riddle. *Sven Lands Sven Folkliv* 1998a;323:145–157.
- SVANBERG I. The use of lichens for dyeing candles: ethnobotanical documentation of a local Swedish practice. *Sven Lands Sven Folkliv* 1998b;324:133–139.
- SVANBERG I. The snow bunting (*Plectrophenax nivalis*) as food in the northern circumpolar region. *Fröðskaparrit: Ann Soc Sci Færoensis* 2001a;48:29–40.
- SVANBERG I. Trade and use of *Gentiana purpurea* in Sweden. *Sven Lands Sven Folkliv* 2001b;124:69–80.
- SVANBERG I. The Sami use of *Lactuca alpina* as a food plant. *Sven Linnésällsk Årsskr* 2002:77–84.
- SVANBERG I. Ethnobiology. In: KULONEN U-M, SEURUJARVI-KARI I, PULKKINEN R. The Saami: a cultural encyclopedia. Helsinki: Suomalaisen Kurkijallisuuden Seura; 2005. p 103–104.
- SVANBERG I. Black slugs (*Arion ater*) as grease: a case study of technical use of gastropods in pre-industrial Sweden. *J Ethnobiol* 2006;26:299–309.
- SVANBERG I. Human usage of mermaid's glove sponge (*Isodictya palmata*) on the Faroes. *J Marine Biol Assoc UK* 2007a;87:1773–1775.
- SVANBERG I. Plant knowledge as indicator of historical cultural contacts: tanning in the Atlantic fringe. In: PIERONI A, VANDEBROEK I. Travelling cultures and plants: the ethnobiology and ethnopharmacy of migrations. Oxford: Berghahn; 2007b. p 227–244.
- SVANBERG I. Jellyfish in north European folk biology. *Sven Lands Sven Folkliv* 2009;131:115–124.
- SVANBERG I, ÆGISSON S. Black guillemot (*Cephus grylle*) in circumpolar folk ornithology. *Scripta Islandica* 2006;56:101–114.
- SZABÓ AT, SZABÓ I, PÉNTÉK J, et al. Ethnobotanical and ethnobiological studies for *in situ* protection of horticultural plant genetic resources in Alp-Balkan-Carpath-Danube. *Acta Horticult* 2003;623:69–86.

- SZULCZEWSKI, JW. Piesn bez konca. Poznan: PSO; 1996 (1997).
- TILLHAGEN C-H. Diseases and their cure among the Swedish Kalderaša Gypsies. *J Gypsy Lore Soc* 1956;3(34):49–62.
- UNCINI MANGANELLI RE, CAMANGI F, TOMEI PE. Curing animals with plants: traditional usage in Tuscany (Italy). *J Ethnopharmacol* 2001;78:171–191.
- VALLÈS J, BONET MÀ, AGELET A. Ethnobotany of *Sambucus nigra* L.: the integral exploitation of a natural resource in mountain regions of Catalonia (Iberian Peninsula). *Econ Bot* 2004;58:456–469.
- VAN ANDEL T, WESTERS P. Why Surinamese migrants in the Netherlands continue to use medicinal herbs from their home country. *J Ethnopharmacol* 2010;127:694–701.
- VARHOL N. Roslini v narodnih povir'ah Rusiniv-Ukrainciv Prášivščini. Prešov: Exco; 2002.
- VICKERY R. *Unlucky plants*. London: Folklore Society; 1985.
- VIEGI L, PIERONI A, GUARRERA PM, VANGELISTI R. A review of plants used in folk veterinary medicine in Italy as basis for a databank. *J Ethnopharmacol* 2003;89:221–244.
- VILBASTE G. *Eesti taimenimetused*. Tallin: ETA Emakeele Selts; 1993.
- VOGL-LUKASSER B, VOGL CR. Ethnobotany as an interdisciplinary method for the study of the management of agro-biodiversity in home gardens of alpine farmers in Eastern Tyrol, Austria. In: BOTTARIN R, TAPPEINER U. *Interdisciplinary mountain research*. Berlin: Blackwell; 2001. p 265–273.
- WALLER PJ, BERNES G, THAMSBORG SM, et al. Plants as deworming agents of livestock in the Nordic countries: historical perspectives, popular beliefs and prospects for the future. *Acta Vet Scand* 2001;42:31–44.
- WIGGEN G. Zoologisk nomenklatur og folketradisjonelle dyrenemningar. *Namn og nemne* 2008;25;11–48.
- ZAGROBELNY M, DREON AL, GOMIERO T, MARCAZZAN G, et al. Toxic moths: sources of a truly safe delicacy. *J Ethnobiol* 2009;29:64–76.

Chapter 13

Ethnomycology: Fungi and Mushrooms in Cultural Entanglements

SVETA YAMIN-PASTERNAK

University of Alaska, Fairbanks, AK

SUBJECTS OF THE THIRD KINGDOM	213
THE BEGINNINGS AND FOUNDATIONAL PRINCIPLES OF ETHNOMYCOLOGY	215
METHODS IN ETHNOMYCOLOGY	216
THE MANY REWARDS OF THE THIRD HUNT	219
MUSHROOMS IN ART AND MATERIAL CULTURE	222
ALL IN ONE: MEDICINE, POISON, AND FOOD	224
CONCLUSION	227
REFERENCES	227

SUBJECTS OF THE THIRD KINGDOM

This chapter explores various uses, beliefs, and practices connected with fungi and mushrooms that exist in different cultures: the study known as ethnomycology. Fungi are a large group of organisms belonging to the kingdom *Myceteae*, some of which unearth the fleshy parts we call mushrooms. In colloquial speech the terms “mushrooms” and “fungi” are often used interchangeably, yet these terms have different meanings. Only a small part of all the fungi that exist in the world actually produce mushrooms. As a fruiting body, similar to a potato or an apple, a mushroom constitutes not an autonomous life form, but a part of a larger organism—the fungus.

Yeasts, molds, and skin infections are also fungal organisms, but fall outside the domain of mushroom hunting, cultivation, and cookery. Many types of yeasts have a long history of being cultivated and used by humans in food and drink preparation, but their roles are very

different from that of mushrooms (see Dugan 2008). The fact that, in some cultures, people avoid mushrooms out of fear that their skin may rot upon contact indicates that in at least some cases they recognize a connection between the fruiting body of a wild fungus and a skin fungus, ascribing a homeopathic “like produces like” quality to the relationship between the two.

Fungi are neither animals nor plants. They constitute a separate kingdom of organisms called *Myceteae*, also known as the “Third Kingdom.” This label is connected to an older understanding of how animals, fungi, and plants are related in their distant evolutionary past, which mistakenly placed the Plant Kingdom—*Plantae*—as the intermediary between *Animalia* and *Mycetae*. Recent research indicates that fungi are genetically closer to animals than they are to plants (Schaechter 1997). Animals and fungi share a common single-celled ancestor. Around 1.1 billion years ago this ancestor’s lineage split from the one that eventually gave rise to plants. While relatively new to modern science, this finding is remarkably consistent with a number of Native American cosmologies, which regard mushrooms as ancestral modes of fully-formed living beings like birds, animals, and fish, but not of plants (Berezkin 1997; Hunn 2008; Lampman 2004). Another recent body of research suggests a connection between human activity and the development of certain groups of fungi. It is not an evolutionary relationship, but rather an ecological one, in which “many of the edible mushrooms most valued by humans thrive in disturbed forests in close proximity to human settlements” (Arora and Shepard 2008: 209).

In the life cycles of many fungi, mushrooms are responsible for initiating reproduction, which they do by releasing microscopic spores. Under favorable ecological circumstances, spores produced by mushrooms germinate into threads of cells called *hyphae*, which then connect with other threads in the soil to form a fungal network called the *mycelium* (plural *mycelia*). These vast, interlacing mycelial networks extend through the soils of practically all life-supporting landmasses. Fungi perform vital ecosystem functions, decomposing and recycling dead matter and carrying essential nutrients to other organisms feeding from the soil. Paul Stamets, whose work has been instrumental in shaping our understanding of the roles mushrooms play in the ecosystem (see Stamets 1999, 2000, 2005), suggests that we think of the mycelial webs as nature’s internet (2005), a networking system which facilitates the flow of information between its many interrelated components.

The importance of mushrooms in the natural environment does not always mirror their standing in the human world. The latter varies widely. Yet, we do find a resemblance in the approaches that social and natural scientists use to advance the understanding of fungi. A forest ecologist may be interested in understanding how certain combinations of mycelia work together to provide soil nutrients favored by a particular species of trees. For an evolutionary geneticist, investigating the speciation of certain fungi may shed light on questions about our planet’s distant past. A study of human attitudes toward fungi, from various standpoints, throughout time and in different parts of the world may help a social scientist illuminate broader cultural and historical processes.

Stamets observes that fungi outnumber plants by at least six times. Of the fungi species that produce mushrooms, so far only about 10% have been identified. What that means, says Stamets, is that “our taxonomic knowledge of mushrooms is exceeded by our ignorance by at least one order of magnitude” (Stamets 2005: 8). It is true that humankind has a long way to go in uncovering the riches of the mushroom world.

At the same time, the number of fungi known and used by people around the world is notable. A conservative estimate shows that 1069 mushroom species are being used for food alone (Boa 2004). People also use mushrooms for medicine, art and craft, ritual practice and

spiritual enlightenment, intoxication and recreation, and a number of other applications ranging from insecticide to soil fertilizer. We now have at least some information about mushroom use, or about cultural attitudes toward mushrooms in places where they are not used, for every continent. In addition to the longstanding Indigenous practices associated with mushroom use found in parts of Africa (Buyck 2008; Chileshe 2005; Dijk et al. 2003; Härkönen et al. 1993; Morris 1984; Pieroni and Price 2006; Saarimäki et al. 1994), Asia (Anderson 1990; Christensen et al. 2008; Imazeki 1973; Imazeki and Wasson 1973; Tsing 2005), Central and South America (Garibay-Orijel et al. 2007; Lampman 2004, 2007b; Montoya et al. 2008; Pérez-Moreno et al. 2008; Plotkin 2000; Shepard et al. 2008; Zent 2008), Middle East (Shavit 2008), Australia (Trappe et al. 2008), and Papua New Guinea (Heim 1972; Reay 1960; Treu and Adamson 2005), recent studies also document how local knowledge, perception, and practices associated with mushrooms change during historical contacts with other cultures or as a response to fairly recent commoditization and global trade (Guissou et al. 2008; Härkönen 1998; Letcher 2007; Sitta and Floriani 2008; Yamin-Pasternak 2007a,b). Among the periodical publications that regularly report on research in ethnomycology are *Economic Botany*, *Ethnobiology*, *Ethnopharmacology*, *International Journal of Medicinal Mushrooms*, and *The Fungi Magazine*. McIlvainea, the now discontinued journal of the North American Mycological Association, carried relevant articles in nearly every issue.

THE BEGINNINGS AND FOUNDATIONAL PRINCIPLES OF ETHNOMYCOLOGY

Although cultural attitudes toward mushrooms have been noted by earlier writers, the establishment of ethnomycology as a distinct area of research is credited to the work of Valentina and Gordon Wasson. It was the contrast in their own feelings that piqued the couple's interest in the subject: Valentina, a Russian émigré, adored mushrooms, while her Anglo-Saxon American husband trembled at the idea of harvesting them for food. One of the important observations the Wassons made is that polarized sentiments toward mushrooms are not restricted to the cultures of their own Anglo-Saxon and Slavic heritages. Many other societies show strong feelings toward mushrooms, either rejecting them with fear and dislike (even disgust) or passionately embracing any opportunity to harvest and consume, or simply converse on the subject of harvesting, cooking, and eating mushrooms. Having defined the former as mycophobes and the latter as mycophiles, the Wassons then attempted to survey as widely as possible the mushroom lore of cultures around the world, in order to find out where each of them stands on the scale of mycophilia and mycophobia (Wasson and Wasson 1957). Since then, a number of authors have commented on the question of cultural attitudes toward mushrooms (see Anderson 2005; Arora 1986; Fine 1998; Lévi-Strauss 1976; Morgan 1995; Schaetchter 1997; Toporov 1985; Yamin-Pasternak 2007). Some criticize the Wasson dichotomy for overly generalizing, allowing little room for gradient and variation within specific communities, where some individuals may know and care more about mushrooms, and others less (Letcher 2007; Mapes et al. 2000).

The scholarship emerging over the course of the past few decades about ways that people think about and utilize mushrooms puts us at advantage over Valentina and Gordon Wasson, whose personal experience with the Third Kingdom has ignited their curiosity enough to define ethnomycology as a field of study. Although contemporary studies reveal "a far broader and more nuanced range of cultural attitudes toward mushrooms" (Arora and Shepard 2008) than we could account for by relying exclusively on the

Wasson dichotomous framework, both the polarity of attitudes in some cases and continuity of others suggest that for a study of mushrooms and people, the notions mycophilia and mycophobia may be worth revisiting.

METHODS IN ETHNOMYCOLOGY

Natural scientists categorize fungi into groups based on how they derive nourishment from the environment: saprophytic fungi decompose dead organic matter, parasitic fungi invade other living organisms, and mycorrhizal fungi form symbiotic interdependent relationships with trees and other plants. Local classifications, used by people who do not employ the language of science, may reflect an awareness of similar ecological principles or may emphasize a different quality of a mushroom, one that carries a meaning in the history and worldview of a people. Thus, for example, the English designation “toadstool” reflects an association between mushrooms and toads, found in Britain and a number of other societies (see Morgan 1995). The polypore (*Ganoderma applanatum*) that many English speakers call the “artist’s conk,” because of its applicability in art and craft, is known as the “monkey seat” in Japan (Wasson 1973). *Armillariella mellea*, called the “honey mushroom” in English after its golden color, is called *opionok* in Russian, which means “the one around a tree stump.” The Russian name, in this case, focuses on the habitat description, as do the Russian common names for some *Leccinum* species like *podberezovik* (“the one under birch” or birch bolete) and *podosinovik* (“the one under an aspen” or aspen bolete). Understanding the ecological principles that mycologists use to identify mushroom groups can be helpful in delineating common patterns and differences in the classificatory systems of mycological scientists and local people.

The identity of a mushroom can be determined with the help of a field guide (cf. Arora 1991; Lincoff 1981). However, many species of mushrooms do look alike, making precise identification difficult at times without a microscopic analysis of spores or tissue. If in addition to ethnographic materials a researcher finds it important to obtain “spore prints” (patterns produced from pressing the underside of a mushroom cap against laboratory glass or a white sheet of paper), or to dry and preserve specimens collected on site, he or she should consider completing a course in introductory mycology prior to heading out into the field. While the fundamentals of collecting mushrooms for identification and long-term storage may not seem terribly complex—that is, each mushroom should be gently wrapped in wax paper, a standardized label containing location and habitat description should be filled out and accompany each specimen, and so on—an overview course that integrates field trips, laboratory and microscopic analyses, and principles of taxonomic identification will produce a greater ability to make decisions about the techniques most appropriate for the nature of his or her research.

When the genus and species cannot be determined, the researcher should at least identify a common group (specifying, e.g., whether the mushroom is a polypore that grows on tree stumps, or a bolete with a porous cap underside, etc.) and note both visual characteristics of the specimen and its physical surroundings. This way an informed reader can delineate at least an approximate or a closely related species. Too much of the literature obscures mushroom identity beyond any possibility of identification. Anthropologists are notoriously bad in this regard, producing scores of ethnographic accounts that do, in one context or another, mention fungi use by local people, but neglect to provide any identification, either local or scientific, and offer little in the way of form or habitat description. This impoverishes the ethnographic portrait of a people, especially in cultures where mushrooms and mushroom

harvesting constitute a significant part of livelihoods. By comparison, we do usually expect authors to say more about local foodways than merely stating that people eat “animals” and “plants.”

Diet is not the only aspect of the human use of mushrooms and other fungi where identification is important. For instance, the “dark shamans” of the Guyana highlands, we are told, eat a diet that includes “certain fungi that are said to aid rapid movement” (Whitehead 2002), in preparation for the cannibalistic *kanaima* hunt. Although a number of psychoactive fungi, predominantly *Amanita muscaria* and *Psilocybe* species, are known to be used in shamanic contexts, acting as agents of the spirit world or inducers of trancelike states, Whitehead’s description constitutes a rare mention of fungi used as a stimulant by individuals practicing one of the most unique forms of human expressions—violent ritual predation of other human beings. A possible candidate is *Cordyceps sinensis*, used by athletes to avert fatigue and in Chinese medicine to promote various areas of health (Boesi 2003; Plotkin 2000; Winkler 2008), but without more information this is only guesswork. Knowing its name would allow us to search for additional practices and beliefs associated with this mushroom, existing in the Guyana highlands, surrounding regions, and other places where it is known to grow. Is it always used to enhance athletic ability or is it also valued as an aphrodisiac, an esculent, or another type of pharmaceutical? Or does it perhaps carry some mythological qualities that make it a subject of avoidance in some cultures? Those are the kinds of questions we would have been able to pursue had we been given a few more clues to decipher the identity of that “certain fungi.”

For a researcher who specifically seeks to advance the field of ethnomycology, documenting and interpreting common mushroom names and taxonomies used by local people is an essential task. To date, one of the exemplary efforts carried out to that end is Aaron Lampman’s (2004) research among the Tzeltal Maya people in Chiapas, Mexico. A manuscript of Lampman’s doctoral dissertation is available through WorldCat Dissertation and Thesis Database (see also (Lampman 2007a,b). Lampman’s findings are integrated in a wider ranging study of the highland Maya ethnomycology (Shepard et al. 2008). In addition to illuminating the subject of the Tzeltal and Tzotzil mushroom classification and use, the study features a combination of field methods that can be employed effectively in designing similar investigations for other parts of the world. “Freelisting,” meaning asking each interviewee to recall all items in a particular category, is a simple and effective means of getting started with documenting local knowledge, in virtually any domain of life. Shepard et al. (2008) employ this technique in combination with asking people to make drawings of the mushrooms they have named. In addition to mushroom types, the researchers solicited freelists of different parts and morphological features of mushrooms. The drawings were later examined to determine which features of specific mushrooms the people like to emphasize most. A field guide by David Arora (1991), who was a co-investigator on this study, was implemented as a general “pictionary,” the mushroom photos from which were shown to people to match local names with the images in the book. This technique is only partly effective because it is limited to information on mushrooms found in both the informant’s and the author’s region. Yet it can provide some insight on the local perception of how similar mushroom varieties differ in form, color, and habitat between the regions. For each listed mushroom the interviewees were also asked to provide information on a range of uses. As with most interview data, it is important to note the gender, age, cultural background, and relevant experience of the informant. The materials collected during the semi-structured interviews were cross-referenced with the authors’ broader ethnographic observations at the area marketplaces, out on mushroom gathering trips, and in individual homes.

The fieldwork of Marja Härkönen (Härkönen 1998, 2002; Härkönen et al. 1993), a Finnish researcher who carried out comparative studies on mushroom collecting in China, Tanzania, and the Karelian regions of Finland and Northwestern Russia, demonstrates how one can design a survey that would draw a broad portrayal of the importance of mushrooms in a population. Her investigation in Karelia (see below) is aimed largely at historical questions, while the work in Tanzania and China focuses on contemporary use. The publication in *Tropical Mycology* (Härkönen 2002) is especially helpful. Most of the questions that Härkönen posed to her study participants can be adopted, with some modifications, if one is to construct an interview protocol to be implemented in a place generally known for its abundant mushroom harvest by local people. These are the questions (2002: 151–159).

- 1 Do you eat mushrooms?
- 2 Who in your family collects mushrooms?
- 3 Who taught you about collecting mushrooms?
- 4 How many different species do you collect for food?
- 5 Please list the names of mushrooms presented.
- 6 Which species tastes the best?
- 7 Is everyone here allowed to collect mushrooms everywhere?
- 8 When and how often are the mushrooms collected?
- 9 How do people prepare mushrooms for food?
- 10 Who in your family prepares mushrooms for food?
- 11 How highly do you value mushrooms as food compared with other foodstuffs such as meat, fish or vegetables?
- 12 Do you preserve mushrooms?
- 13 Are mushrooms sold in the market places in this region?
- 14 Do you use mushrooms for purposes other than for food, for instance as medicine?
- 15 Is there a traditional healer in your village who uses mushrooms? How are they used?
- 16 Are there poisonous mushrooms in this region?
- 17 Have misidentifications occurred, leading to mushroom poisonings?
- 18 How do you recognize a poisonous mushroom?
- 19 Do you know any beliefs, stories or fairytales about mushrooms?

Going through a list of pointed questions may prove less rewarding than a more open-ended dialog. Simply stating the subject of interest, shared by the researcher and the interviewee, oftentimes generates a flowing narrative. By Härkönen's own admission, inquiring as to which member of a household prepares the mushrooms is not particularly fitting in rural Tanzania, where women do all the cooking. The question of valuing mushrooms over other food sounds "foolish" (Härkönen 2002: 156) in Hunan, where (in contrast to the role of the main dietary staple during the rainy season in Tanzania) mushrooms are part of many mixed dishes that include a number of different vegetables and meats. In some cultural divisions of labor between genders, mushrooms do constitute an anomaly, being the only crop that is harvested and prepared by men, in a culture where women do most of the work associated with food and cooking.

Finally, it is useful to consider the framework used by social scientists to study other single substances. Anthropologist Sidney Mintz, whose renowned study of sugar demonstrates how one commodity can connect the lives of people in the Old and New World (see Mintz 1986), says this kind of inquiry can be attempted at two levels. One approach, which we have already discussed in connection with the Lampman (2004), Shepard et al. (2008), and Härkönen (2002) studies, is to focus fundamentally on the substance: in our case that would amount to studying how specific mushrooms are found, identified, harvested, processed, and used by a group of people or across cultures. We can also focus on the substance's social history and meanings to illuminate broader processes (see Mintz and Du Bois 2002). A study with documentation of culturally salient species as its primary goal can be carried out in the form of a structured or semi-structured survey.

THE MANY REWARDS OF THE THIRD HUNT

A recent literature survey provides a record of 1154 fungi consumed in 85 countries (Boa 2004). While the Russian tradition attracts unprecedented attention from English-language authors, for many societies where mushroom hunting is known to exist (including the Indigenous peoples of Siberia), its role in the culture and livelihood is poorly understood.

Aside from the extensive body of research on the shamanic use of several psychoactive species (Furst 1972; Gartz et al. 1996; Guzman 2008; Harner 1973; Letcher 2007; Ott 1993; Schultes 1940; Wasson 1962, 1968), anthropological research on the diversity of the human uses of fungi lags behind the far more extensive work of foresters, resource economists, and rural development specialists. Scholars working in those disciplines produce detailed analyses of the economic and ecological impact of mushroom gathering (Boa 2004; Christensen 2008; Montoya 2004; Rammeloo and Walley 1993).

One of Gordon Wasson's works draws a long list of societies in which the origin of mushrooms is attributed to the striking of lightning bolts (Wasson 1956). Mushroom consumption is forbidden by the Dharma-sūtras (Simoons 1998) and raises concerns for the Jewish Kashrus laws. Historically and to this day, mushrooms are a luxurious commodity priced for the privileged in restaurants and retail and, at the same time, a last-resort food for the rural poor.

The polarity in attitudes toward mushrooms once discovered by Wasson in cultures occupying different ecological niches can also be found in neighboring populations. For example, mushroom hunting—with local knowledge of as many as 300 species—is widespread in Mexico and Guatemala, to a lesser extent in Honduras, and is said to be all but absent in other parts of Central America, despite the continuous presence of tree species symbiotic with mycorrhizal fungi. In Spain, wild mushroom collection prevails among the Catalans and Basques (Boa 2004; Schaechter 1997). A great variation in mushroom use is found in Africa. Mushrooms constitute a very important source of food in Zambia, providing several months of sustenance for the rural poor (Chileshe 2005; Richards 1939), but no interest in picking—for consumption or trade—is reported for nearby Angola, characterized by similar woodlands (Boa 2004). In Nigeria, we find opposing attitudes among the mycophagous Yoruba people (Oso 1975) and the Fulani, who reject mushrooms as food (Wasson 1954). For Tanzania, Härkönen lists the Chagga, Arusha, Meru, and Maasai as groups whose members “would not put mushroom in their mouths” (Härkönen 2002: 151).

In certain cases, mushroom use in a culture is a result of a recent influence, connected with a specific movement of people or ideas. During the Soviet period, for example,

mushroom picking became a common, even beloved, activity among a number of Indigenous populations in Siberia and the Far East. They adopted this practice from the influences of Russian and Ukrainian settlers in the Soviet North, whose cuisines are famous for their love of mushrooms (Caldwell 2004; Chamberlain 1983; Schaetcher 1997; Soloukhin 1968; see Fig. 13.1). In the past, each of these groups had their own reasons for avoiding mushrooms: some associated them with malevolent metaphysical entities, while others considered them food for the reindeer, not humans. Currently, throughout much of the post-Soviet North, mushroom hunting is regarded as an inherently local practice, especially by the younger generations (Yamin-Pasternak 2007; Ziker 2002).

Some of this Russian mushroom fever appears also to have extended westward, over the Finnish border. When I discuss the subject with Finnish people in the United States, especially those of the generation born around the time of World War II, I am told that it is the Russian influence alone that is responsible for the popularity of wild mushrooms in Finland. However, one of Härkönen's (1998) studies reveals several trajectories through which, at different points in history, mushrooms were gaining a stronghold in Finnish foodways. According to Härkönen, it is the use of *Lactarius* species, which diffused into eastern Finland through the postwar evacuees from the Finnish territory, that was absorbed by the Soviet Union. In western Finland, on the other hand, the influence of the adjacent Sweden created a widespread preference for *Boletus edulis* and chanterelles which, during the nineteenth century reign of the French-born King Johan XIV, were increasingly finding their way onto the Francophile menus of the Swedish social elite. Following World War II, a number of governmental and independent organizations concerned with food security



Figure 13.1 A Chukchi resident in the village of Nunligran, located on the Russian coast of the Bering Sea, is preparing a fresh harvest of *Leccinum versipelle*, known among the Indigenous residents as “mountain mushroom” and among the Russian settlers as “aspen bolete.” Photograph by Sveta Yamin-Pasternak (2004).

in Finland joined their efforts in promoting wild mushroom harvesting in all parts of the country, encouraging people to learn how to identify and prepare a wide variety of species.

The contemporary settlement of Russian or Russified populations abroad brings mushroom cookery to countries where in the past it either has not been practiced at all or not on the scale that we can observe today, giving rise to some of the most unexpected culinary fusions, commodity flows, and cultural crossroads. In Israel, now that its Jewish immigrants from the Soviet Union number over a million people, mushroom cookbooks and identification guides written in Russian and Hebrew languages are finding a new niche in the publishing market. This, along with the online mushroom hunter forum that covers over 600 relevant subjects and displays a logo of the Israeli flag with a handsome bolete mushroom protruding from the center of the Star of David (see *Mushrooms of Israel*), should serve as powerful evidence to the skeptics of the fact that mushrooms even can be found in that part of the world. Anticipating disbelievers among her readership, Russian immigrant Ella Edelshtein (1983), whose cookbook of 293 recipes focuses mostly on the mushrooms she collects in Israel, urges local hunters to head out into the woods promptly at the start of the season. “Wait a week or two,” warns Edelshtein “and you will arrive to a place with no mushrooms in sight and leave with a wrong assumption: all that [talk about mushrooms] was nothing but lies or wishful thinking” (Edelshtein 1983: 9).

The overall rise in the global international trade of forest products brings an influx of commercial buyers and harvesters of wild mushrooms to many rural areas (Fig. 13.2). In some of those areas mushroom picking has been a long-standing local custom, while in others it is seen for the first time.



Figure 13.2 In interior Alaska, during a bumper year of the commercially valuable morel mushrooms, genus *Morchella*, mushroom buyers depended largely on “circuit pickers,” that is, migrant harvesters of wild forest products, whereas the majority of local people gave preference to more traditional subsistence activities such as fishing. Photograph by Sveta Yamin-Pasternak (2005).

“Forest products go in and out of market value, but residents continue to appreciate them as landscape features because of their local, subsistence uses,” writes Anna Tsing (2005: 184) about the dynamics of foraging in the Meratus Mountains of Borneo. Other studies tell a different story. In the town of Ozumba, central Mexico, the increasing external demand for local wild mushrooms appears to be fostering the preservation and even expansion of knowledge among local people, who collect mushrooms for both the marketplace and for home, still valuing the species that do not have commercial value. Yet in another town surveyed during the same study, local interest in mushrooms has all but disappeared, and most collecting is done for commercial purposes by pickers coming from outside the region (Pérez-Moreno et al. 2008).

Although in recent years, largely in response to a growing preoccupation with natural foods, we are seeing an expanding variety of wild mushrooms marketed in western countries, cultivated mushrooms continue to dominate the industry. Mushroom cultivation is seen by many as an opportunity to create a local enterprise which requires relatively minor infrastructure and is capable of recycling certain types of agricultural and industrial waste, utilized as a mycelium substrate. Hence we are seeing development agencies together with private investors introducing mushroom farming to rural communities throughout the world. Similar to the wild commercial harvest coming to areas where mushroom collecting may or may not have been practiced before, mushroom cultivation is finding its way to places in Australia, previously unfamiliar to mycophagy (Hirst 2008) with the exception of some uses by Aborigines (Lepp, undated; Trappe 2008), as well as to villages in Siberia, southern Africa, China, Japan, and Thailand, known for their mushroom loving cuisines.

While many mushroom growers operate on relatively small scale, selling through local vendors and specialty retail, it is typically large operations that supply the most common supermarket varieties like the white button, crimini, and Portobello mushrooms (all three belong to the species *Agaricus bisporus*, each representing a different stage of growth). Unfortunately for mushroom growers, many varieties considered choice in world cuisines (such as boletus, matsutake, chanterelle, truffles, among others), are mycorrhizal, growing symbiotically with the roots of particular plants, thereby making cultivation difficult or impossible. Yet we do find examples where the entire habitats are managed, either via local practices or national policies, with a goal of fostering the proliferation of these mushrooms. In preindustrial Japan, firewood collecting and other human activities promoted the establishment of pine groves rich in matsutake. With other types of fuel taking the place of the firewood, these favorable disturbance activities became less consistent, causing a decline in matsutake production (Saito and Mitsumata 2008). Anthropologists Anna Tsing and Shiho Satsuka are both members of the Matsutake World Research and examine the key differences in forest management approaches in the US and Japan. Whereas the US regulations often prohibit or restrict mushroom harvesting, viewing it as comparable to timber exploitation bans in protected wildernesses, the Japanese regard their matsutake-producing forests as mass scale nature orchards, proper management of which provides a nurturing habitat for one of Japan’s most cherished mushrooms (Tsing and Satsuka 2008).

MUSHROOMS IN ART AND MATERIAL CULTURE

Mushrooms are featured in a number of art traditions around the world. The Registry of Mushrooms in Works of Art (<http://www.mykoweb.com/art-registry/index.html>; cited in Schaetcher 2009) includes over 800 European artworks, from the 1300s to contemporary times. Among non-Western examples are the ancient mushroom stone sculptures of

Mesoamerica (see Mayer 1977; Wasson 1980) and the Pegtymel petroglyphs in Russia's Eastern Arctic (Dikov 1999 [1971]), as well as Japanese Netsuke figurines from various time periods (Symmes 1995). The characters accompanying these depictions include figures of deities, humans, and animals, each offering some revelations while also raising questions about the role of mushrooms (or particular mushroom species) in the societies that created these objects. A triptych block print by Utagawa Kunisada, the famous Japanese artist from the Edo epoch, shows a group of servants collecting mushrooms for their masters having a picnic at the bottom of the hill (Fig. 13.3).

The connection between mushrooms and prosperity that exists in Japan today—a gift baskets of matsutake mushrooms carefully laid atop of bank notes (Mogu Mogu 2007) is one of its iconic representations—appears to be a long-standing association. Japanese admiration for mushrooms also becomes apparent in several literary traditions, one of the most prominent being *haiku* poetry. The two collections that have been examined for the subject feature over 300 verses dedicated to the physical form, the aroma, and the taste of different mushrooms, as well as the pleasure of the activity of gathering (Blyth 1973). By contrast, the Tokugawa period books called *kinpu*—“fungi records” aimed to present mushrooms as a natural wonder, taking more of a scientific rather than a poetic stance. The *kinpu* texts spread over the course of the nineteenth century and range “from albums in which amateur enthusiasts drew and wrote about mushrooms to careful and extensive descriptions by scholars” (Imazeki and Wasson 1973). In most *kinpu*, each mushroom description is accompanied by a wood block print that illustrates the species, often at different angles.

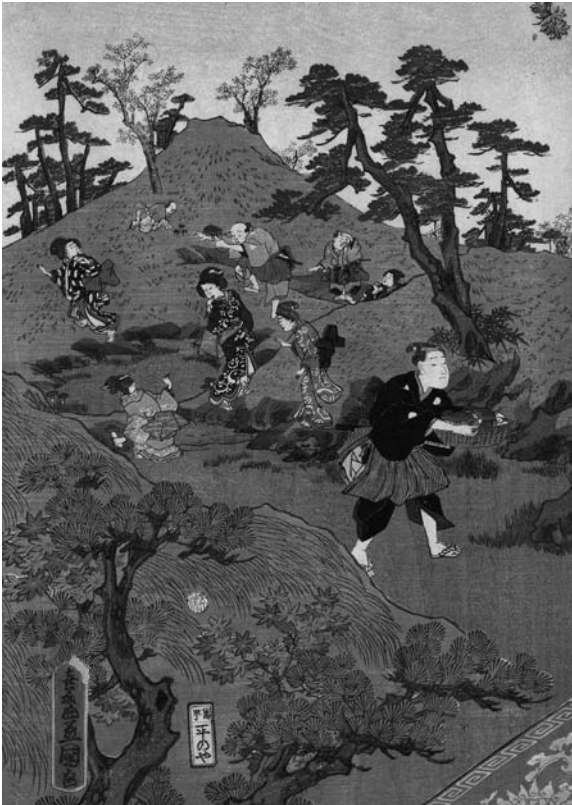


Figure 13.3 Fragment of a block print by Utagawa Kunisada (1786–1865), depicting mushroom collectors. Courtesy of the Wasson Collection, Harvard University. (See color insert.)

Examples of artful carrying vessels for mushrooms or mushroom products can be found in contemporary shopper catalogues, as well as in museum collections. The Smithsonian Museum of Natural History holds a number of fungal ash boxes collected in western Alaska around 1880 (see Nelson 1983 [1899]). Made of ivory, bentwood, and baleen and adorned with feathers, zoomorphic designs, and intricate carving patterns, these “snuff-boxes” were intended to hold and transport the ash of polypore *Phellinus igniarius*, brought into this treeless tundra area from regions further inland (Blanchette 2001; Blanchette et al. 2002). The distances traveled to obtain it, and the fine workmanship of the snuffboxes, indicate that this substance was highly valued. Ash of *Phellinus igniarius* is mixed with chewing tobacco to enhance its flavor and effect. It is still popular in western Alaska, especially among the Indigenous elders.

Besides being an artwork subject, mushrooms can also function as art supplies. Fiber artists, especially weavers, value the broad spectrum of warm earthly hues that can be derived from dyeing wool with sulfur tufts, jack-o-lanterns, several species of *Dermocybe*, and other mushrooms. In the United States, this medium was popularized by Miriam Rice (1980, 2008; see also International Mushroom Dye Institute: <http://www.mushroomsforcolor.com>) who began using locally harvested mushrooms for color while teaching art classes in Mendocino, California. Rice’s successive tryouts with these innovative media are documented in the book *Mushrooms for Color* (1980) which, shortly after its publication, became an international hit among weavers in North America, Australia, and Europe. Weavers in Scandinavian countries were eager to incorporate this method of dyeing wools into Nordic designs, commonly used for sweaters and outer garments.

ALL IN ONE: MEDICINE, POISON, AND FOOD

Andy Letcher, the author of the book *Shroom*, objects to the term “mycophobia,” coined by the Wassons, claiming that we should not describe as a “phobia” the inclination to avoid potentially dangerous behavior (Letcher 2007). True, people can and do get hurt from the effects of reckless mushroom consumption, as they do from reckless driving, downhill skiing, and crossing the street on the red light. However, few people would suggest it is rational never to leave home in order to avoid traffic accidents.

Consider *Amanita muscaria*, the fly agaric, whose bright red cap adorned with white polka dots makes it arguably one of the most recognizable members of the Third Kingdom (see Fig. 13.4).

Simply running its name, scientific or common, through an internet search engine will drown a curious browser in theories, testimonies, and conspiracies surrounding the social standing of this mushroom and its medicinal, visual, nutritional, and psychoactive properties. Delving into each of these aspects paints a provocative example of a mushroom that is used as a revered strength enhancer and shaman’s tool among the Indigenous peoples of Siberia (Saar 1991; Wasson 1968), a recreational intoxicant of the counterculture movement in Western countries on both sides of the Atlantic (Letcher 2007), and a delicious edible in parts of Japan (Rubel and Arora 2008; Wasson 1973). The majority of Ukrainians, Russians, and Byelorussians—the peoples said to be famous for their knowledge of different mushroom properties—fearfully reject *Amanita muscaria* as a food, claiming that ingesting it internally can be deadly, although they do apply a fly agaric infusion externally as a remedy for ailing bone joints, skin, and eyes (Moskalenko 1987; Pietkiewicz 1938). These are just a few of the many documented uses and cultural association of this mushroom.



Figure 13.4 Although *Amanita muscaria* is known as a psychoactive mushroom, this batch, collected during an annual Northern California Mendocino Coast Foray, was cooked for dinner following a simple detoxification procedure (see Rubel and Arora 2008). Photograph by Sveta Yamin-Pasternak (2008). (See color insert.)

When people first start learning about mushrooms, they are often all too eager to place each one into a set category. They want to know whether it is edible, poisonous, medicinal, or hallucinogenic. Sometimes, as in the case of *Amanita phalloides*, we can say with certainty that this mushroom is not edible, as ingesting it in any form causes quick and fatal damage to the liver and kidneys. Most of the time, however, edibility is not a quality that is inherent in a species, but one defined by cookery, methods of processing and preservation, ways and quantities of ingestion, as well as the symbolic associations carried in a culture. A boiling method used to prepare *Amanita muscaria* in the Nagano prefecture of Japan helps rid the mushroom's flesh of its toxins, which are completely water soluble (Rubel and Arora 2008). Yet, the mushroom loving Slavs, whose cookery prescribes the boiling step as part of virtually any mushroom preparation, will not consider doing the same with the fly agaric, as its potential harm is believed to be unavoidable and omnipresent. Fly agaric imagery inhabits the landscapes of many Russian folk tales, where it is associated with the underworld, danger, and death.

The distinction we draw between toxic, psychoactive, medicinal, or hallucinogenic mushrooms is not absolute either. The definition here largely depends on the intention of the user. In a number of Indigenous cultures, *Amanita muscaria* and several *Psilocybe* species are used by healers and visionaries, who consider these mushrooms to be the time-tested, revered sources of spiritual power, intended to be consumed by specialized members of the society. Gordon Wasson's book *Soma* furnishes an extensive list of bibliographic entries, mostly accompanied by excerpts from the original texts, of early explorers and observers documenting the use of *A. muscaria* among the Indigenous peoples of Siberia and the Russian Far East. Mexican scholar Guston Guzman (2008), recognized as one of

world's foremost authorities on the genus *Psilocybe*, lists 14 principal species important to at least seven Indigenous groups in Mexico, of which Mazatecs, Mixes, and Nahuatlans exhibit the greatest diversity of species used in ritual ceremonies. In such a context, it would probably be more appropriate to call these mushrooms psychoactive, rather than toxic or hallucinogenic. On the other hand, the criminal codes in the majority of Western states clearly consider the consciousness-altering capabilities of *Psilocybe* harmful and dangerous, and are therefore more likely to regard its psychoactive qualities as poisonous or toxic. Since they were initially documented in the 1960s, psychoactive mushrooms have been a popular item at festival events, where they are usually called hallucinogenic, psychedelic, or simply “magic” (Letcher 2007). Yet, despite fact that in Western cultures they are largely associated with recreational drugs, many people claim that ingesting psychoactive mushrooms enhances their spiritual wellbeing and understanding of the world around them, and even inspires a better behavior (Griffith and Richards 2008).

Calling a mushroom “medicinal” can also allude to several meanings. Many kinds of mushrooms, mushroom extracts, and mushroom infusions are utilized in medical systems around the world (Hobbs 1986; Stamets 2005; see Moerman 1998 for Native American uses). Some are prescribed for specific afflictions; others are considered to be general boosters for the nervous system, immunity, or metabolism. Among the internationally marketed species, renowned for their healthful qualities are *Grifola frondosa* (common names “maitake” and “hen of the woods”; see Fig. 13.5), (Chinese “*ling zhi*,” Japanese “*reishi*”), and *Cordyceps sinensis* (usually called “cordyceps” in the English vernacular); these are just a few of the myriad medicinal fungi used by healers.



Figure 13.5 While the retail price of this 6000 mg (0.21 ounce) bottle of *Grifola frondosa* extract for the author's dog, recommended by a holistic veterinarian as an immune system booster to assist the dog's struggle with bone cancer, averages around US\$80, the home-pickled batch of the same mushroom (also known as Maitake and Hen of the Woods) was freely available to pick in a forest. In the cookery of Russian and other Slavic cultures pickled mushrooms are ingested as a “chaser” with a shot of hard liquor. Photograph by Sveta Yamin-Pasternak (2009). (See color insert.)

In the healing practices that utilize psychoactive mushrooms, it is usually not the patient but the healer who ingests the mushrooms, in order to draw knowledge of possible causes and cures from the experience spawned from the reaction. It should be noted that the use of psychoactive mushrooms or other substances is not a universal means to achieve the condition known as the shamanic state of consciousness (Harner 1980), which can also be attained through a combination of other techniques, like drumming, chanting, specific motion, or concentration (Siikala 1978; Siikala and Hoppal 1992). Lastly, mushroom medicine can be administered not only to heal humans or other creatures, but also to improve the health of whole ecosystems. This is the central idea behind the work of Paul Stamets (2005), whose monumental book *Mycelium Running: How Mushrooms Can Help Save the World* introduces us to the techniques of “mycofiltration” and “mycoremediation,” which involve enriching a habitat with specific fungi that are capable of absorbing environmental pollutants in order to promote the restoration of healthy soils in contaminated or damaged forests.

As we have seen from the example of *Amanita muscaria* and its status among the Russians, a culture that generally celebrates itself as mycophilic may be unjustly (from an outsider’s point of view) discriminatory toward a specific mushroom. It may also accord a rather low grade to the mushrooms considered choice by others. For instance, morel mushrooms, which are priced exuberantly in the high-end restaurants and markets of the United States, Switzerland, and France, are rated in the lowest category by the Russians, whose beloved *Boletus edulis* are, in turn, shunned by the mycophiles of Mexico (Elizondo 1991) and Japan (Imazeki 1993). “A meal of wild mushrooms is a delicacy in Switzerland or the United States but a necessity in Malawi,” points out Eric Boa (2004: 51). This may well be true, but in acknowledging that, we should remember that foods harvested as a necessity can be also valued as delicacies in the same culture.

CONCLUSION

This chapter discusses a range of subjects, and how one can learn more about them by asking what specific cultures or human groups think about mushrooms and which, how, and for what purpose different species are used. It provides an overview of some methodological suggestions for tackling these questions. For a researcher working in a place where mushroom uses are abundant, documentation of local knowledge may become a major effort. Yet those who encounter absence of use should not walk away without asking why that is so. The culture of a people who appear not to use mushrooms probably features an aspect of history or worldview capable of shedding light on an aspect of ethnomycology. One just has to ask the questions.

REFERENCES

- ANDERSON EN. Everyone eats: understanding food and culture. New York: New York University Press; 2005.
- ANDERSON EN. The food in China. New Haven (CT): Yale University Press; 1990.
- ARORA D. Mushrooms demystified: a comprehensive guide to the fleshy fungi. Berkeley (CA): Ten Speed Press; 1986.
- ARORA D. All that the rain promises and more: a hip pocket guide to western mushrooms. Berkeley (CA): Ten Speed Press; 1991.
- ARORA D, SHEPARD GH, JR. Mushrooms and economic botany. *Econ Bot* 2008;62(3):207–212.
- BEREZKIN YE. Predstavleniya o gribakh u Indeitsev Ameriki [Ethnomycological concepts among the American Indians]. *Kunts Etnograf [Kunstkamera Working Papers in Ethnography]*, 1997;11:119–132.
- BLANCHETTE RA. Fungus ashes and tobacco: the use of *Phellinus igniarius* by the Indigenous people of North America. *Mycologist* 2001;15:4–9.

- BLANCHETTE RA, RENNER CC, HELD BW, ENOCH C, ANGSTMAN S. The current use of *Phellinus igniarius* by the Eskimos of Western Alaska. *Mycologist* 2002;16:142–145.
- BLYTH RH. Mushrooms in Japanese verse. *Trans Asia Soc Japan 3rd Ser* 1973;11:93–106.
- BOA E. Wild edible fungi: a global overview of their use and importance to people. Rome: Food and Agriculture Organization of the United Nations; 2004.
- BOESI A. The dbyar rtswa dgun 'bu (*Cordyceps sinensis* Berk.): an important trade item for the Tibetan population of the Litang District, Sichuan Province, China. *Tibet J* 2003;XXVIII(3):29–42.
- BUYCK B. The edible mushrooms of Madagascar: an evolving enigma. *Econ Bot* 2008;62(3):509–520.
- CALDWELL ML. Not by bread alone: social support in the new Russia. Berkeley: University of California Press; 2004.
- CHAMBERLAIN L. The food and cooking of Russia. Harmondsworth: Penguin; 1983.
- CHILESHE RA. Land tenure and rural livelihood in Zambia: case studies of Kemena and St. Joseph [PhD dissertation]. Bellville: University of the Western Cape, 2005.
- CHRISTENSEN M, BHATTARAI S, DEVKOTA SH, LARSEN HO. Collection and use of wild edible fungi in Nepal. *Econ Bot* 2008;62(1):12–23.
- DIJK HV, ONGUENE NA, KUYPER TH.W. Knowledge and utilization of edible mushrooms by local populations of the rain forest of South Cameroon. *J Hum Environ* 2003;32(1):19–23.
- DIKOV NN. Mysteries in the rocks of ancient Chukotka: petroglyphs of Pegtymel'. Shared Beringian Heritage Program. Anchorage, AK: US Department of the Interior, National Park Service; 1999 [1971].
- DUGAN FM. Fungi in the ancient world: how mushrooms, mildews, molds, and yeast shaped the early civilization of Europe, the Mediterranean, and the Near East. St. Paul (MN): APS Press; 2008.
- EDELSHTEIN ELLA. Gribnoe zastol'e: 293 retsepta original'nykh gribnykh bliud [The Mushroom Feast: Recipes for 293 Unique Mushroom Dishes]. Khaifa: E. Edelshtein; 1983.
- ELIZONDO MG. Ethnobotany of the southern tepehuan of Durango, Mexico. I: edible mushrooms. *J Ethnobiol* 1991;11(2):165–173.
- FINE GA. Morel tales: the culture of mushrooming. Cambridge (MA): Harvard University Press; 1998.
- FURST PT. *Flesh of the gods: the ritual use of hallucinogens*. New York: Praeger Publishers; 1972.
- GARIBAY-ORJEL R, CIFUENTES J, ESTRADA-TORRES A, CABALLERO J. People using macro-fungal diversity in Oaxaca, Mexico. *Fung Divers* 2007;21:41–67.
- GARTZ J, TAAKE C, FALK B. *Magic mushrooms around the world: a scientific journey across cultures and time, the case for challenging research and value systems*. Los Angeles (CA): LIS Publications; 1996.
- GRIFFITH RR, RICHARDS WA, JOHNSON MW, McCANN UD, JESSE R. Mystical-type experiences occasioned by psilocybin mediate the attribution of personal meaning and spiritual significance 14 months later. *J Psychopharmacol* 2008;22(6):621–632.
- GUISSOU KML, LYKKE AM, SANKARE P, GUINKO S. Declining wild mushroom recognition and usage in Burkina Faso. *Econ Bot* 2008;62(3):530–539.
- GUZMAN G. Hallucinogenic mushrooms in Mexico: an overview. *Econ Bot* 2008;62(3):404–412.
- HÄRKÖNEN M. Uses of mushrooms by Finns and Karelians. *Int J Circumpol Health* 1998;40:40–55.
- HÄRKÖNEN M. Mushroom collecting in Tanzania and Hunan (Southern China): inherited wisdom and folklore of two different cultures. In: WATLING R, FRANKLAND JC, AINSWORTH AM, ISAAK S, ROBINSON CH, editors. *Tropical Mycology. Volume 1: Macromycetes*. Wallingford (UK): CAB International; 2002.
- HÄRKÖNEN M, BUYCK B, SAARIMÄKI Y, MWASUMBI L. Tanzanian mushrooms and their uses. 1. *Russula. Karstenia* 1993;33:11–50.
- HARNER M. *Hallucinogens and shamanism*. New York: Oxford University Press; 1973.
- HARNER M. *The way of the shaman*. San Francisco (CA): Harper & Row; 1980.
- HEIM R. Mushroom madness in the Kuma. *Hum Biol Oceania* 1972;1:170–178.
- HIRST G. Mushrooms gaining in popularity and availability; 2008. Available at: <http://www.couriermail.com.au>. Accessed 2009 Mar 16.
- HOBBS C. *Medicinal mushrooms: an exploration of tradition, healing and culture*. Summertown (TN): Botanica Press; 1986.
- HUNN ES. *A Zapotec natural history*. Tucson: University of Arizona Press; 2008.
- IMAZEKI R. Japanese mushroom names. *Trans Asia Soc Japan 3rd Ser* 1973a;11:26–80.
- IMAZEKI R, WASSON RG. Kinpu, mushroom book of the Tokugawa Period. *Trans Asia Soc Japan 3rd Ser* 1973b;11:81–92.
- INTERNATIONAL MUSHROOM DYE INSTITUTE. Available at <http://www.mushroomsforcolor.com>. Accessed 2008 Apr 11.
- LAMPMAN AM. Tzetel ethnomycology: naming, classification and use of mushrooms in the highlands of Chiapas, Mexico [PhD Dissertation]. Athens: University of Georgia; 2004.
- LAMPMAN AM. Ethnomycology: medicinal and edible mushrooms of the Tzetel Maya of Chiapas, Mexico. *Int J Med Mushr* 2007a;9(1):1–5.
- LAMPMAN AM. General principles of ethnomycological classification among the Tzetel Maya of Chiapas, Mexico. *J Ethnobiol* 2007b;27(1):11–27.
- LEPP, HEINO. Australian Fungi website. Australian National Botanic Gardens. Available at <http://www.anbg.gov.au/fungi/>. Accessed 2009 June 28.
- LETCHER A. *Shroom: a cultural history of the magic mushroom*. New York: Ecco; 2007.
- LÉVI-STRAUSS C. Mushrooms in culture: apropos of a book by R.G. Wasson. In: *Structural Anthropology. Volume II*. New York: Basic Books; 1976.

- LINCOFF G. The Audubon Society field guide to North American mushrooms. New York: Knopf, Random House; 1981.
- MAPES C, DE F, BANDEIRA FPS, CABALLERO J, GOES-NETO A. Mycophobic or mycophilic? A comparative ethnomycological study between Amazonia and Mesoamerica. In: STEPP, JR, WYNDHAM, FS, ZARGER RK, editors. Ethnobiology and biocultural diversity. Athens (GA): International Society for Ethnobiology; 2000.
- MAYER KH. The mushroom stones of Mesoamerica. Ramona (CA): Acoma Books; 1977.
- MINTZ SW. Sweetness and power: the place of sugar in modern history. New York: Viking; 1986.
- MINTZ SW, DU BOIS CM. The anthropology of food and eating. *Annu Rev Anthropol* 2002;31:99–119.
- MOERMAN DE. Native American ethnobotany. Portland (OR): Timber Press; 1998.
- MOGU MOGU. Mycorrhizal translations: a mushroom manifesto. *Paper presented at the American Anthropological Association meeting*. Washington (DC); 2007.
- MONTOYA A, HERNÁNDEZ N, MAPES CH, KONG A, ESTRADA-TORRES A. The collection and sale of wild mushrooms in a community of Tlaxcala, Mexico. *Econ Bot* 2008; 62(3):413–424.
- MORGAN A. Toads and toadstools: the natural history, folklore, and cultural oddities of a strange association. Berkeley (CA): Celestial Arts; 1995.
- MORRIS B. Macrofungi of Malawi, some ethnomycological notes. *Bull Br Mycol Soc* 1984;18:45–57.
- MOSKALENKO SA. Slavic ethnomedicine in the Soviet Far East. Part I: herbal remedies among Russians/Ukrainians in the Sukhodol Valley, Primorye. *J Ethnopharmacol* 1987;21:231–251.
- MUSHROOMS OF ISRAEL. Online forum. Available at <http://gribisrael.borda.ru>. Accessed 2009 May 3.
- NELSON EW. The Eskimo about Bering Strait. Washington (DC): Smithsonian Institution Press; 1983 [1899].
- OSO B. Mushrooms and the Yoruba people of Nigeria. *Mycologia* 1975;67(2):311–319.
- OTT J. Pharmacothoeon: etheogenic drugs, the plant sources and history. Kennewick (WA): Natural Products; 1993.
- PÉREZ-MORENO J, MARTÍNEZ-REYES M, YESCAS-PÉREZ A, DELGADO-ALVARADO A, XOCONOSTLE-CÁZARES B. Wild mushroom markets in Central Mexico and a Case Study at Ozumba. *Econ Bot* 2008;62(3):425–436.
- PIERONI A, PRICE LL. Eating and healing: Traditional food as medicine. Haworth Press; 2006.
- PIETKIEWICZ C. Kultura duchowa polesia Rzeczyckiego [The spiritual culture of the Rechitsa woodlands]. Warsaw: Towarzystwo Naukowe Warszawskie; 1938.
- PLOTKIN MJ. Medicine quest: in search of nature's healing secrets. New York: Viking; 2000.
- RAMMELLOO J, WALLEYN R. The edible fungi of Africa south of the Sahara: a literature survey. *Scripta Bot Belg* 1993; 5:1–62.
- REAY M. "Mushroom madness" in the New Guinea highlands. *Oceania* 1960;XXXI:137–139.
- RICE M. Mushrooms for color. Eureka (CA): Mad River Press; 1980.
- RICE M. Mushrooms for dyes, paper, pigments and myco-stix. Forestville (CA): Mushrooms for Color Press; 2008.
- RICHARDS A. Land, labor, and diet in Northern Rhodesia: an economic study of the Bemba tribe. London: Oxford University Press; 1939.
- RUBEL W, ARORA D. A study of cultural bias in field guide determinations of mushroom edibility using the iconic mushroom, *Amanita muscaria*, as an example. *Econ Bot* 2008;62(3):223–243.
- SAARIMÄKI T, HÄRKÖNEN M, MWASUMBI L. Tanzanian mushrooms and their uses. 3. *Termitomyces singidensis*, sp. *Karstenia* 1994;34:13–20.
- SAAR M. Ethnomycological data from Siberia and Northeast Asia on the effect of *Amanita muscaria*. *J Ethnopharmacol* 1991;31:157–173.
- SAITO H, MITSUMATA G. Bidding customs and habitat improvement for Matsutake (*Tricholoma matsutake*) in Japan. *Econ Bot* 2008;62(3):258–268.
- SCHAECHTER E. In the company of mushrooms: a biologist's tale. Cambridge (MA): Harvard University Press; 1997.
- SCHAECHTER E. Mushroom sellers in Renaissance and Baroque paintings. *Fungi* 2009;2(1):12–13.
- SCHULTES RE. Teonanacatl: the narcotic mushroom of the Aztecs. *Amer Anthropol* 1940;42:429–443.
- SHAVIT E. Truffles roasting in the evening fires: pages from the history of desert truffles. *Fungi* 2008;(1):18–23.
- SHEPARD GH, JR, ARORA D, LAMPMAN A. The grace of the flood: classification and use of wild mushrooms among the highland Maya of Chiapas. *Econ Bot* 2008;62(3): 437–470.
- SIKALA A-L. The rite technique of the Siberian shaman. Helsinki: Suomalainen Tiedeakatemia; 1978.
- SIKALA A-L, HOPPAL M. Studies on Shamanism. Helsinki: Finnish Anthropological Society; 1992.
- SIMOONS FJ. Plants of life, plants of death. Madison (WI): University of Wisconsin Press; 1998.
- SITTA N, FLORIANI M. Nationalization and globalization trends in the wild mushroom commerce of Italy with emphasis on porcini (*Boletus edulis* and allied species). *Econ Bot* 2008; 62(3):307–322.
- SOLOUKHIN VA. Tretia okhota [The third hunt]. Moscow: Sovietskaya Rossiia; 1968.
- STAMETS P. Psilocybin mushrooms of the world. Berkeley (CA): Ten Speed Press; 1999.
- STAMETS P. Growing gourmet and medicinal mushrooms. Berkeley (CA): Ten Speed Press; 2000.
- STAMETS P. Mycelium running: how mushrooms can help save the world. Berkeley (CA): Ten Speed Press; 2005.
- SYMMES EC. Netsuke: Japanese life and legend in miniature. Tokyo: Tuttle Publishing; 1995.
- TOPOROV VN. On the semiotics of mythological conception about mushrooms. *Semiotica* 1985;53(4):295–357.
- TRAPPE JM, CLARIDGE AW, CLARIDGE DL, LIDDLE L. Desert truffles of the Australian Outback: ecology, ethnomycology, and taxonomy. *Econ Bot* 2008;62(3):497–506.

- TREU R, ADAMSON W. Ethnomycological notes from Papua, New Guinea. *McIlvainea* 2005;16(2): 310.
- TSING AL. *Friction: an ethnography of global connection*. Princeton (NJ): Princeton University Press; 2005.
- TSING AL, SATSUKA S, FOR THE MATSUTAKE WORLDS RESEARCH GROUP. Diverging understandings of forest management in Matsutake science. *Econ Bot* 2008;62(3):244–253.
- WASSON RG. Letter to M.B. Nsimbi, Provincial Education Office, Kampala: Uganda [unpublished]. Africa File, Wasson Ethnomycology Collection. Cambridge (MA): Harvard University Botanical Library; 1954.
- WASSON RG. Lightning-bolt and mushrooms: an essay in early cultural exploration. For Roman Jakobson: Essays on the Occasion of His Sixtieth Birthday. The Hague: Mouton; 1956.
- WASSON RG. The hallucinogenic mushrooms of Mexico and psilocybin: a bibliography. *Bot Mus Leafl Harvard Univ* 1962;202:25–73.
- WASSON RG. *Soma: divine mushroom of immortality*. New York: Harcourt Brace Jovanovich; 1968.
- WASSON RG. *Mushrooms and Japanese culture*. Tokyo: Asiatic Society of Japan; 1973.
- WASSON RG. *The wondrous mushroom: mycolatry in Mesoamerica*. New York: McGraw-Hill; 1980.
- WASSON V, WASSON RG. *Mushrooms, Russia, and history*. New York: Pantheon Books; 1957.
- WHITEHEAD NL. *Dark Shamans: Kanaima and the poetics of violent death*. Durham (NC): Duke University Press; 2002.
- WINKLER D. Yartsa Cunbu (*Cordyceps sinensis*) and the fungal commodification of Tibet's rural economy. *Econ Bot* 2008;62(3):291–305.
- YAMIN-PASTERNAK S. An ethnomycological approach to land use values in Chukotka. *Etud Inuit Stud* 2007a;31(1–2): 121–141.
- YAMIN-PASTERNAK S. *How the devils went deaf: ethnomycology, cuisine, and perception of landscape in the Russian North* [PhD dissertation]. Fairbanks: University of Alaska; 2007b.
- ZENT EL. Mushrooms for life among the Joti in the Venezuelan Guayana. *Econ Bot* 2008;62(3):471–481.
- ZIKER JP. *Peoples of the tundra: northern Siberians in the post-Communist transition*. Prospect Heights (IL): Waveland Press; 2002.

Chapter 14

Ethnoecological Approaches to Integrating Theory and Method in Ethnomedical Research

NINA L. ETKIN

Department of Anthropology, University of Hawai'i, Honolulu, HI, (Nina Etkin passed away on 27 January 2008)

TAMARA TICKTIN

Department of Botany, University of Hawai'i, Honolulu, HI

HEATHER L. McMILLEN

Health and Habitat Program, People and Plants International, Inc., Essex Junction, VT

INTRODUCTION	232
THEORETICAL PERSPECTIVES	233
ETHNOGRAPHY IN ANTHROPOLOGICAL TRADITIONS	233
STUDY PARTICIPANTS	234
PARTICIPANT OBSERVATION	234
INTERVIEWS AND QUESTIONNAIRES	234
MARKET SURVEYS	236
IDENTIFICATION OF BOTANICAL SPECIES AND ETHNOSPECIES	237
COMBINING ETHNOGRAPHIC AND ECOLOGICAL APPROACHES	238
EXAMINING IF AND HOW ECOLOGICAL FACTORS INFLUENCE PLANT COLLECTION AND PHYTOCHEMISTRY	238
IDENTIFYING ECOLOGICAL FACTORS THAT INFLUENCE MEDICINAL PLANT COLLECTION	238
COMPLEMENTING FIELD OBSERVATIONS WITH MANIPULATIVE EXPERIMENTS	239
DISTINGUISHING ENVIRONMENTAL FROM GENETIC INFLUENCES	240

IDENTIFYING OPTIMAL CONDITIONS FOR MEDICINAL PLANT CULTIVATION	240
IDENTIFYING THE ECOLOGICAL IMPACTS OF MEDICINAL PLANT HARVEST	241
UNDERSTANDING MEDICINAL PLANT HARVESTS AS LOCAL MANAGEMENT SYSTEMS	241
ASSESSING VARIATION IN MEDICINAL PLANT HARVEST PRACTICES	241
EXPERIMENTAL APPROACHES TO ASSESSING MEDICINAL PLANT HARVEST IMPACTS	242
OBSERVATIONAL APPROACHES TO ASSESSING MEDICINAL PLANT HARVEST IMPACTS	244
PARTICIPATORY ECOLOGICAL RESEARCH METHODS	245
REFERENCES	245

INTRODUCTION

This chapter uses an integrated biocultural perspective, which reflects an understanding that local knowledge emerges from and undergirds the relations among people, plants, other species, material cultures, ideologies, and physical environments. For ethnobiology, ethno-pharmacology, and related fields, integrated approaches drive more powerful analyses than those studies that offer little more than catalogues of plants and their uses (Etkin 1993; Etkin and Elisabetsky 2005; Etkin and Ticktin 2005, 2009). More sophisticated research designs emphasize overlapping contexts of plant and animal use (Etkin and Ross 1997). The interpretation, utility, and conservation of plants are influenced not only by knowledge of daily activity patterns, which can be learned relatively quickly, but also by their extension into weeks, months, seasons, and years.

Ethnobiological knowledge varies among and within populations. Integrated research strategies explore those ranges of variation and test assumptions about who holds knowledge and how knowledge is transmitted. Research should be designed to explore actual harvest and management practices for plants and animals and not just descriptions of such practices, since they are not necessarily parallel. Comprehensive perspectives question and test the merits of normative models of people–plant and people–animal interactions, such as consensus analysis (Moerman 2007), in which consistent patterns of use within and across cultures are taken as good predictors that those species can be “corroborated” bioscientifically. Consensus can be artificially forced, and masks the natural heterogeneity of human circumstances. Traditional uses emerge from the internal logic of local paradigms and do not need the imprimatur of bioscience.

Researchers must recognize that local knowledge and use of ethnomedicines are embedded in larger systems and are shaped by many factors, including political–economic influences, disease experience, and local explanatory models for disease. Demand for ethnomedicines is affected by pandemics such as HIV/AIDS, drug resistant malaria, and limited access to clean water, as well as more culturally specific concepts such as children’s diseases and witchcraft. Research on ethnomedicines must also include these dimensions. Worldwide, about 10–18% of native plant species are used medicinally (Schippman et al. 2002). People make deliberate choices in harvesting and managing specific types for medicinal use.

THEORETICAL PERSPECTIVES

A biocultural perspective provides the overarching framework for ethnomedical and ethnoecological research. Biocultural research integrates bioscientific material (e.g., on disease, evolution, ecology) with interpretive and descriptive contributions from ethnography to examine people and plants on a range of scales: from the species level and particular ethnographic field sites to whole ecosystems including the human populations within them.

Biocultural research may investigate the co-evolution of biological and cultural diversity, the influence of human–environment interactions on human health, and how these issues relate to resource management, among other topics. Johns (1996) examined the biocultural evolution of human dietary behavior and the origins of medicine and hypothesized that there are both biological and cultural components in humans' adaptive responses to the ingestion of plant chemicals. He describes how the cultural evolution of the Aymara people and the evolution of the potato in the Andes are intimately related and have co-evolved through the processes of human selection for increased flavor and decreased toxicity in *Solanum* species. Etkin's (2006) treatment of the overlapping context of foods and medicines throughout human biological and social evolution uses specific examples of plants, animals, and cuisines to advance our understanding of the cultural constructions and biochemical potential of ingested biological material.

ETHNOGRAPHY IN ANTHROPOLOGICAL TRADITIONS

Outlined here is a foundation for field research that draws on the anthropological tradition of ethnography. While ethnography commonly is misconstrued as simply fieldwork, a foundational component in the development of classical ethnography was to describe what was learned and observed deductively, that is, with reference to *a priori* anthropological theories. Several primary and accessory methods are “triangulated”: discrete techniques, not limited to three, are applied in sequence or concurrently to create an organic inquiry in which the same botanical domain (medicine identification, preparation, harvest methods) is explored through different formats. This tests data reliability and validity by assessing whether the researcher “got it right”—that is, elicited the same information—not whether study participants change responses or forget.

A spaced sequence of rapid appraisals might capture some seasonal, social, and ecological variation. Botanists and others who are not interested in in-depth ethnography can take advantage of rapid assessment, keeping in mind these limitations and other characteristics (Trotter and Schensul 1998):

- The study sample size is small.
- The study is narrowly bounded, for example, to one domain of use, or to a small number of plants.
- The research focuses on consensus and other broad patterns, rather than on intracultural complexity, to determine commonly used plants, sources, and salient ecological parameters.
- Goals are problem oriented to contribute to programs or policies, for example, government conservation efforts.
- Sector sampling—for example, household heads, farm owners, forest managers—does not plumb the range and scale of community heterogeneity.

Study Participants

Issues of intellectual property rights, benefit sharing, and informed consent have been increasingly clarified and codified by researchers and their institutions, governments, Indigenous groups, and international entities (Etkin in press; Sampath et al. in press; Sillitoe 2006). Even small communities that appear to be homogeneous may house significant asymmetries in access to resources, including knowledge and practices related to plants. Many research designs replicate biomedical and Western paradigms that privilege specialists (e.g., healers). In the case of ethnomedicines, targeting healers overlooks health action that begins with home- or self-care and ranges through levels and types of expertise, and may involve community-wide activities. Research from Tanzania shows that rural farmers, mothers, medicinal plant vendors, and commercial harvesters can be as knowledgeable (or more so) than specialist healers about popularly sold medicinal plants. The inclusion of only healers would have missed important plants, harvesting techniques, and medicinal plant habitats (McMillen 2008). The same holds true for other use domains for which specialists, titled or not, represent only part of the range of knowledge and practice of the community. Because human communities are not “human laboratories,” random and other “objective” samples might not be meaningful for any data collection beyond superficial matters. Researchers who are familiar with the community with which they work should be able to select samples that represent the ranges of ethnicity, language, occupation, religion, education, and so on. Researchers should also describe *whose* knowledge they are discussing. Knowledge of plants and animals varies by gender (Pfeiffer and Butz 2005), age (Müller et al. 2009), training and livelihood (Ghimire et al. 2004; Joyal 1996), wealth, and so on. It is important to explain how participants were identified and how widely the particular knowledge is distributed. Esoteric knowledge and plant or animal harvesting practices of just one individual should not be represented as an entire community’s shared knowledge system or resource management strategies. A minimum of three independent observations for each behavior or knowledge claim has been used as a standard for describing shared knowledge that is part of a local ecological knowledge system (Davis and Wagner 2003; Johns et al. 1990; McMillen 2008).

Participant Observation

Researchers wishing to understand ethnomedical practices should enter a community slowly, especially as concerns about biopiracy cast us in shadow throughout much of the world. A short-spaced sequence of several preliminary visits provides opportunities to explain research goals in more detail and to organize the logistics of establishing residence in the community. Participant observation begins on the first day that the researcher contacts the community and continues for the duration of the study (Bernard 2006). Rapid appraisal offers fewer possibilities to observe local ecology and community life, but participant observation still is an important, ongoing component of that approach.

Interviews and Questionnaires

It may not be obvious how medicines work from a local perspective, but this can be better understood through in-depth ethnographic research.

Efficacy is brought about in a context of belief and expectation and through social communication and interaction. It has a processual nature and is initiated by preparatory activities like prescribing, buying, collecting, and preparing the medicine. Therefore, the therapeutic effect of a medicine cannot be reduced to its chemical substance. Its “total drug effect” depends also on nonchemical attributes of the drug such as its color, name, and provenance; on properties of the recipient and prescriber; and on the situations in which the medicine is delivered and consumed.

(van der Geest et al. 1996: 167)

For example, among the Iroquois, plants with hook-like structures that are sticky have “ensnaring/capturing qualities” and are used to cure cold sores, venereal diseases, and diarrhea—all of which are perceived as running or escaping things. Plants with these qualities are also seen as effective for returning an unfaithful lover and enticing or “hooking” buyers (Moerman 2007).

Healers understand their actions to affect the efficacy of the medicines they use. In many places the adherence to harvesting protocols is paramount. If these are not followed by the harvester, the medicine is not expected to work because it will not have the power of the healer or his/her associated spirits (McMillen 2008). In Nigeria, Yoruba healers sing to their medicines to make them effective. In Burundi, healers claim that their personal power—not a power inherent in the plants—makes the medicines work (van der Geest et al. 1996). A plant’s power to heal is also indicated by its overall appearance, specifically its size and vigor, as well as its organoleptic qualities (Etkin 2006; Ghimire et al. 2004; Gollin 2004; McMillen 2008; Shepard 2004). Often, stronger, more pungent tastes and smells are preferred, which can also indicate biochemical qualities.

Like disease, therapeutics is a process, the early phases of which might be directed at determining etiology or expelling disease agents via emesis, sweating, or sneezing (Etkin 1988). Through cultural domain analysis researchers seek to understand how the study participants perceive groups of entities that appear to be related: plants, symptom categories, and medicinal plant habitats.

Higher, specialized levels of medicinal plant knowledge have been demonstrated in northwestern Nepal with healers who have more knowledge than commercial collectors (Ghimire et al. 2004), and in Marrakech, Morocco where vendors with more years of experience knew more than those with fewer years of experience (Martin et al. 2007). Higher levels of medicinal plant knowledge have also been associated with increased age, for example in Brazil (Begossi et al. 2002; Monteiro et al. 2006) and Tanzania (Luoga et al. 2000a). Lower levels of formal education have been correlated in Brazil and elsewhere with higher levels of medicinal plant knowledge (Voeks and Leony 2004).

In some contexts, women hold higher levels of plant knowledge (Begossi et al. 2002; Monteiro et al. 2006; Voeks and Leony 2004), while in others men hold more (Joyal 1996; Luoga et al. 2000a). More specifically, gender also influences plant knowledge based on habitat type (Hanazaki et al. 2006; Kyoshabire 1998), use of plant (Luoga et al. 2000b), and life form (Caniago and Siebert 1998; Lewis and Elvin-Lewis 1990). Ethnicity and length of contact in a given environment are also linked to people’s relationships with specific plant habitats and to local ecological knowledge. Exploring and verifying how knowledge differs among social groups can help in assessing locally innovated techniques in resource management and conservation planning (Ticktin and Johns 2002), especially as concerned with ethnomedicines, which are typically considered the purview of elders and traditional healers.

For ethnobiological and ethnomedical research, discourse methods can be applied to conversations that occur during sourcing plants in markets or forests, and preparing species

for use. Narrative analysis is another method used by ethnographers of language: researchers listen to individuals tell, sing, or act out a story. This overlaps with oral history. Text analysis works with written accounts: school children's essays; newspapers; and novels, letters, and dictionaries that represent Indigenous literatures. Several group methods are distinguished by their structure, context, and goals (Bernard 2006). At least one community interview (CI) is convened very early in the study as researchers introduce themselves, or are introduced, and describe general research goals. In view of the large audience, the venue is typically a public site such as a town square, church, or school. The CI is structured by what the researcher wants to convey, and is flexible to permit community input. Researchers should be clear about their interests and can describe their own personal experiences that have led to the questions they are pursuing. Researchers should also be forthcoming about their own biases and stakes in the project. In attendance are all or a large representation of the community; the format is typically question-and-answer.

After gaining acceptance from the community, researchers may convene focus groups to explore particular topics. A challenge is to assure the group that there are no wrong answers and that, while consensus may emerge, a heterogeneity of views is welcome. Factorial design might be appropriate: a group of eight would represent two genders, two ethnic groups, two occupations, and two residential sites.

Natural site interviews might be scheduled or spontaneous, as the researcher encounters people grouped for crop harvest or healing, hunting, dyeing cloth, or weaving baskets. Depending on the community size, several groups of farmers, healers, hunters, dyers, and weavers, and so on, might be organized, as group demographics and size impact the social dynamic.

A standard ethnobiological quantification gauges the local significance of a plant or animal, of a conservation measure, or a collection strategy based on the fraction of participants who use the plant or animal, effect conservation in that way, and collect in that manner. Significance is defined by the researcher, taking into account local parameters. Beyond that, detailed information allows the compilation of other indices. Commonly used species can be ranked on a Saliency Index. The Use Value of a species is calculated from the overall utility of a plant based on how respondents designate all plants and their applications along a transect or in a single site.

Preference Ranking (PR) assigns a mean numerical value to each plant based on how significant respondents consider that species to be as revealed by requesting respondents to order species using criteria such as abundance, apparency, or flavor. Direct Matrix Ranking (DM) compounds PR by considering two or more criteria. Using DM, the researcher can set a standard that will serve cross-cultural comparisons. That standard more realistically represents the selection of plants in real-life circumstances.

Market Surveys

For ethnomedical research designed to inform conservation and management, ethnomedicines that invariably appear in market settings and enjoy a high volume trade deserve special consideration. Focusing on the most popularly sold medicinal plants and animals allows the exploration of which organisms and habitats may be at risk from overharvest, and how knowledge and practices related to those organisms may affect their ecological status. However, the identification and evaluation of such species is complex, due to the informal, heterogeneous, and clandestine nature of the medicinal plant trade.

Economic and commercial data can be derived by following guidelines for market surveys and inventories (Cunningham 2001; Martin 1995; Trager 1995). These should include taking stock of what types of vendors are present and where, and conducting semi-structured interviews with vendors to learn some of the most salient plants and/or animals and to understand the market chain and structure.

Working in Tanzania, McMillen (2008) interacted with most vendors for at least four months before she felt comfortable asking to inventory their stocks. (She had known some of the vendors for years.) She wanted to understand the context of the lists the inventories would generate, and more importantly, she wanted to ensure that the vendors understood the goals of her research, which did not include bioprospecting—something that needed to be clarified. She also wanted to ensure vendors were confident that sharing information with her would not put their livelihoods or knowledge at risk. She progressed slowly and transparently and never asked about the uses of the plants, which put people at ease and made them more interested in fully participating.

Not all studies can afford four months of groundwork before conducting complete inventories of vendors' stocks. An acceptable compromise may be to establish rapport and ask vendors about the most important plants instead. The plants that vendors identify as most important are often those that are actually most apparent in their stocks (McMillen 2008; Williams 2007). In fact, Williams (2007) found that the more traders that sell a plant, the more likely they are to cite it as popular.

Identification of Botanical Species and Ethnospecies

Researchers should accompany commercial harvesters, vendors, and healers as they collect medicinal plants. Cunningham (2001: 19) recommends cross-checking names with different people and comparing the results from different methods. He describes three methods: (1) the “artifact/interview” technique, where a particular item or artifact, or in our case medicine, is the focus of the interview and participants are asked the names of the materials used to make that item; (2) the “inventory/interview” where particular plant specimens are the foci of interviews with participants who are asked their names and uses; and (3) the “walk in the woods” approach, where participants are asked the names and/or uses of specific whole plants in the field that have been identified by “key helpers” (Cunningham 2001: 19).

To verify ethnospecies–botanical species names, McMillen (2008) prepared voucher specimens and had a minimum of four different individuals from at least two different locales identify the plants by ethnospecies. These four individuals were either present at the time of collection of the voucher specimen or they were shown a prepared voucher specimen and asked about all the names that applied to it. The species' scientific names were verified at the National Herbarium of Tanzania (NHT) where vouchers were deposited. This helped to reconcile the taxonomic name when, for example, she suspected that multiple ethnospecies referred to the same botanical species or when one ethnospecies referred to multiple botanical species. In South Africa, Cunningham (2001) recorded nine Zulu names for the medicinal plant species *Curtisia dentata*. In the Afromontane forest in Uganda, he also encountered multiple cases in which a single local name applies to multiple botanical species, some of which were rare and some of which were widespread (Cunningham 2001).

COMBINING ETHNOGRAPHIC AND ECOLOGICAL APPROACHES

Examining if and How Ecological Factors Influence Plant Collection and Phytochemistry

The extensive literature on the botany and chemistry of phytomedicines includes a growing corpus of research on the relationships between environment and the presence or absence of medicinal plants (McCune and Johns 2002; Stepp and Moerman 2001; Voeks 1996). There is still a paucity of information on how/which ecological factors influence decisions about where and when to collect individual medicinal plants or plant parts, and what the implications of these decisions are (for an example, see McCune and Johns 2007). How and why do people make decisions about where and when to collect medicinal plants? How does medicinal plant phytochemistry, thus pharmacologic potential, vary with ecological conditions? How might anthropogenic landscape-level ecological changes alter the pharmacologic potential of plants? What are the optimal conditions for cultivation? How do wild harvested and cultivated medicinal plants compare?

Identifying Ecological Factors that Influence Medicinal Plant Collection

Genetic variation can account for a large proportion of phytochemical variation among and within individual plants, populations, and environments. This might be especially true for medicinal plants that have been selected by diverse cultures. However, some of the secondary chemical components, or combination of components, that are responsible for pharmacologic activity vary significantly over space and time in response to environmental factors. Ecological factors such as light and nutrient availability, competition, and the intensity of herbivory can influence the production of phytochemicals (Fiebert and Langheim 1988; Hoft et al. 1996; McCune and Johns 2007; Osier and Lindroth 2001; Salmore and Hunter 2001). In some species, the production of defense chemicals such as alkaloids, many of which have medicinal value, are induced by insect herbivory (Fordyce 2001; Salmore and Hunter 2001). The impact of insect herbivory, in turn, can be influenced by solar radiation (Fiebert and Langheim 1988), moon phase, surrounding vegetation, and other factors. In addition, the production of phytochemicals can vary over seasons, times of day, and phases of the plant life cycle (Bennet et al. 1990; Jarzonmoski et al. 2000; Maldonado et al. 2008). Similarly, phytochemical variation can be due to environment–genotype interactions (Osier and Lindroth 2001); environmental factors can also trigger the expression of certain genes. Thus, plant chemistry and pharmacologic potential can vary seasonally and among populations occurring in different environments and microenvironments, and therefore collectors often use ecological and environmental cues when making decisions on how, when, and where to harvest medicinal plants.

However, these decisions can also be strongly influenced by socioeconomic factors. Decisions to collect particular species from certain environments instead of from others can especially be influenced by land tenure and ease of access. The most utilized habitats are not necessarily the most preferred ones. The preferred time to harvest may not be the same time as most harvesting occurs if it conflicts with the time when crops need to be harvested. Time periods such as the shifting month of Ramadan in Islamic cultures, when harvesters are fasting, may mean that little harvesting occurs, even though it falls during

an optimum month for harvest. More harvesting may occur when crops fail because of the need to supplement livelihood strategies.

While the collection of many species is specific for time of year (e.g., spring, dry season), life-cycle phase (e.g., before flowering), or environmental conditions (e.g., north-facing slopes, beneath trees, high altitude), other guidelines for harvesting may be less obvious due to the guarded nature of ethnomedical knowledge. In Tanzania, McMillen learned of a healer who told her patient to return once he had found the feather of a certain bird; only then would she provide his medicine. When questioned as to what role the feather played in the composition of the medicine, the healer smiled and explained that although the medicine is purely plant based, that bird migrates at the same time as the plant is flowering. The feather brought by the patient reminded the healer to harvest the plant she needed at the appropriate time. By asking for the feather, she both protected her specialized knowledge and reminded herself of what she needed to harvest for that patient whom she had seen a month earlier.

Simple ecological field methods can be carried out to identify and document ecological or environmental factors that vary between preferred versus non-preferred places or times to collect medicinal plants, and to test their effects. To assess whether ecological differences are linked to preferred and non-preferred collection sites/times, several factors should be quantified. If the active constituents of a species are thought to play a role in plant defense against insect herbivory, the intensity of insect herbivory can be measured in a set of preferred versus non-preferred populations. This can be done very simply, for example, by using a grid to measure leaf area eaten by insects as a percentage of total leaf area. Other ecological factors that can be quantified include: canopy cover or light transmission, soil nutrient levels and moisture, temperature, rainfall, and composition and density of surrounding vegetation. Canopy cover is an indicator of light availability and can be measured with a densitometer or camera with a hemispherical lens. Alternatively, light transmission can be quantified using quantum light sensors. Some soil nutrient levels can be measured using simple field kits; otherwise, soil samples can be collected for laboratory analyses, and soil moisture can be measured with special probes. Precipitation is measured with a pluviometer set up in each site. Composition and density of surrounding vegetation can be assessed, for example, by randomly selecting a specified number of equal-sized plots and recording the number and identity of all species within them.

Environmental comparisons can be made between preferred versus non-preferred collection sites and/or times to identify ecological factors that differ significantly. These measures can be complemented with chemical assays to assess whether there is significant chemical variation among sites and/or times. However, while some of the chemical compounds responsible for the activities characterized for a plant may play ecological roles—such as defense against herbivory, pollinator attraction, and allelopathy—the roles played by many secondary chemical compounds are not known.

Complementing Field Observations with Manipulative Experiments

By identifying the factors that differ significantly across preferred and non-preferred collection sites and/or times, we gain insight into which of these may be related to observed differences in the pharmacologic potential and/or perceived potency of plants. To link these ecological factors more directly to changes in plant chemistry, controlled manipulative experiments are needed. If insect herbivory was identified to be significantly higher in

preferred gathering sites, experiments should be designed to test this hypothesis by exposing plants to various intensities of insect herbivory. This can be accomplished using simple methods, for example, by using mesh enclosures to exclude all or some insects from sets of plants. Light levels can be experimentally controlled and compared through the use of shading (employing mesh, thatch, and other materials). Soil nutrient levels can be manipulated by variable augmentation with fertilizers. To minimize differences due to genetic diversity, these experiments should be conducted with clones (for example, vegetative cuttings) or with the seeds of known crosses. DNA analysis would better clarify this issue, but the focus of this discussion is field research.

Distinguishing Environmental from Genetic Influences

Genotypic variation also can contribute to differences in phytochemistry among individual plants and populations. In the case of wild-harvested plants, if significant phytochemical variation between preferred and non-preferred sites/times of collection is observed, comparisons of ecological conditions should be complemented with experiments that can help distinguish between environmental and genetic variation. Common Garden and Reciprocal Transplant experiments (Gibson 2002) offer simple, appropriate methods for testing genetic versus environmental influences on observed differences in phenology (in this case, phytochemistry). In common garden experiments seeds or clones from populations of the species in question are collected and planted together in a common garden environment; traits that appear only in one or more populations but never in a common garden are thought to be environmentally induced. Similarly, in reciprocal transplant experiments, if plant A evidences B-like phytochemical changes when transplanted to the habitat of plant B, environmental influences are invoked.

Identifying Optimal Conditions for Medicinal Plant Cultivation

These methods can be employed to explore potential anthropogenic impacts on medicinal plants. Human-induced disturbances such logging, grazing, and fire alter both biotic and abiotic factors that affect plant growth and might, thus, affect the phytochemistry of plant populations. Medicinal plant cultivation in homegardens has been promoted as means to help improve human health, and the cultivation of species that are overharvested in the wild has been promoted in agroforestry and other cultivation systems. Herbivore population composition and density, nutrient supplies, light availability, and other ecological factors can vary significantly among populations located in forests, homegardens or agroforestry systems. This variation, in turn, has potential consequences for phytochemistry. Many healers maintain that cultivated plants do not have the same potency as wild-collected counterparts. By identifying optimal collection sites (according to medicinal plant collectors) and determining some of the ecological conditions that distinguish them, these methods can help guide the design of appropriate cultivation strategies.

The relationships among collector decision making, ecological variables, and perceived potency are highly complex. The methods outlined above are not aimed necessarily at identifying cause and effect relationships but rather at providing insight into some of the ways in which these variables may be connected. Phytochemical composition is one of various factors that can influence the perceived effectiveness of medicinal plants. It is often difficult to assign constituents to specific actions or ecological functions.

Identifying the Ecological Impacts of Medicinal Plant Harvest

For millennia people have depended on the harvest of medicinal plants not only for local needs but also for commercial trade, and today many Indigenous and other rural communities continue to do so. While the harvest of many medicinal plant species may be ecologically sustainable, heavy subsistence or commercial harvest can lead to decreases in, or extinction of, local populations. This has led to local concerns over the decreased availability of key medicinal resources as well as to larger conservation concerns for many species (Ghimire et al. 2008; Schippman et al. 2002; Ticktin 2004). What are the ecological and conservation implications of harvesting medicinal plants? How and why do harvest strategies and their impacts vary according to cultural, socioeconomic, and ecological factors? Under what conditions—ecological, cultural, socioeconomic, or other—might medicinal plant collection have the greatest potential for sustainability? By addressing these questions, ethnobiologists can help design conservation strategies for medicinal plant use that are both culturally and ecologically appropriate.

Understanding Medicinal Plant Harvests as Local Management Systems

In some communities the commercial harvest of a given medicinal plant species may be a new commercial endeavor and there are no pre-existing harvesting traditions. However, in many communities the harvest of medicinal plants for subsistence or commercial purposes is part of a long established tradition. Medicinal plants often form part of larger local resource management systems. To understand medicinal plant harvests we must therefore understand the larger management context in which they occur. Local resource management practices are based on knowledge of the local environment, and consist of sets of practices, techniques, and tools for managing local ecosystems and their elements. They are guided by social institutions and shaped by local worldviews, and cannot be interpreted out of context (Berkes 2008). Throughout this chapter we use the term “local” to refer to Indigenous and other cultural communities who have resided in a particular location for a long period of time.

Local resource management systems are usually complex and can involve the manipulation of plant resources in many different ways and at differing ecological, spatial, and temporal scales (Alcorn 1981; Casas et al. 1996; Turner et al. 2000). Practices that achieve this include enhancement (such as transplanting individuals to areas where they have better chances of survival, sowing of propagules) as well as protection and encouragement (such as weeding competing species, pruning, digging soil around the roots, mulching, coppicing, opening forest canopies to let in more light). In South India, the use of traditional low intensity fire management is thought to help maintain high levels of production of the medicinal fruit *amla* (*Phyllanthus emblica*), by reducing hemiparasite load (Setty et al. 2008). All of these practices should be documented in any study of medicinal plant management.

Assessing Variation in Medicinal Plant Harvest Practices

Local resource management practices are often highly variable among and within local communities, as well as over time, in response to shifting sociopolitical, cultural, and

environmental influences. Identifying this variation in medicinal plant harvesting practices is critical as it can result in very different ecological impacts. The potential of individual plants to survive, grow, and reproduce will be influenced differently if collection occurs during different times of the year (e.g., during the wet or dry season), at different plant life stages (e.g., pre- or post-reproduction), for diverse plant parts (e.g., the branch holding its leaves or just the leaves), at varied intensities (e.g., many times in one year and nothing the next, a few times each year), and in different environments, such as dry forest versus gallery forests (cf. Gaoue and Ticktin 2008; Guedge et al. 2007; Ticktin 2004). Spatial patterns of harvest (both within populations and across landscapes) can affect regeneration and have important implications for conservation. Further variation in ecological impacts can result from different management practices such as thinning or weeding populations to reduce competition for light or nutrients, light manipulation such as trimming overhead branches, fire management, and grazing.

The documentation and assessment of variation in medicinal plant harvest and management practices can be achieved through the integration of ethnographic and ecological methods, including participatory ecological research. Comparative research within and among both human and ecological communities is needed to identify the links between specific practices, their drivers, and their ecological impacts. To the extent that plant management strategies are not necessarily explicit, and that many plants are managed outside of official harvest activities, important information will be generated: through participant observation, with a variety of participants under diverse socioeconomic circumstances, including land tenure; in varied environments; and at different times of the year.

Actual harvest and management of plants can (and usually does) differ from the way it is described during interviews. Although harvesters may not intentionally mislead the researcher, they may describe optimal—not actual—harvesting, or leave out a number of steps because they seem too obvious. There are differences in knowledge and practice, or between “active and passive knowledge” (Ghimire et al. 2004). Researchers need to observe multiple actual harvesting by a number of different harvesters. In Tanzania, McMillen found that healers and other medicinal plant harvesters described how culturally guided collection methods (including taboos) that articulated an ethos of resource conservation are followed in ideal situations, but she observed that their application is highly context specific and their practice is irregular (McMillen 2008). In Nepal, Ghimire and coauthors (2004) observed that commercial collectors who had extensive experience harvesting and a good knowledge of plant lifecycles and reproduction did not differ in their harvest techniques from those without such knowledge.

Meaning and knowledge may not emerge in interviews and discussions that take place apart from harvesting events. The strictest taboos, if unobserved, confer no ecological benefits. Researchers’ presence impacts the behaviors of people and the characteristics of the environment in which they work. Staged collection events may be done primarily for the benefit of the researcher and bear little resemblance to harvesters’ actual management practices. An understanding of the social institutions and worldviews that guide resource management practices will emerge from rigorous design, application, and triangulation of ethnographic methods and exacting data analysis.

Experimental Approaches to Assessing Medicinal Plant Harvest Impacts

Harvesting medicinal plants can have ecological impacts at different ecological scales (Ticktin 2004) and therefore can be assessed in different ways. For instance, the harvest

of plants or plant parts (roots, bark, seeds, leaves, latex) can alter an individual plant's vital rates (survival, growth, reproduction), sometimes by affecting its physiology. For example, the harvest of frankincense resin (*Boswellia papyrifera*) in Ethiopia can decrease rates of flower and fruit production and increase production of non-viable seeds (Rijkers et al. 2006). Changes in these vital rates can result in changes in population size, structure, and dynamics over the longer term, and in plant–plant or plant–animal interactions. For example, even low levels of root harvest of the Himalayan medicinal herb *Nardostachys grandiflora* can lead to population decline (Ghimire et al. 2008). Heavy and long-term harvesting of medicinal plants, often in conjunction with other management strategies, can alter community structure, composition, and diversity, as well as ecosystem processes. In South India, dry deciduous forests subject to high intensity extraction of medicinal plants have lower tree species richness and higher proportions of wind-dispersed versus animal-dispersed understorey plants and seedlings than comparable areas of forest with lower intensity of medicinal plant harvest (Ganeshiah et al. 1998; Murali et al. 1996).

Field experiments to test the ecological effects of management might entail comparing a given management practice to a control, for example, comparing how variations on a harvest practice affect a variable such as reproduction, for example, tapping medicinal tree resin at different intensities. Experiments also can be carried out at different ecological scales, from individual plants to landscapes, depending on the interests of the researcher and the local communities.

At the ecological scale of individuals, the effects of harvesting medicinal plants can be tested on measures of individual growth, survival, and reproduction. Working with local harvesters, diverse patterns of harvest can be simulated and experimentally applied to replicate plants; 30 individual plants per treatment is often considered an appropriate sample size. Since for many species the effects of harvest might be observed only after repeated harvesting, ideally these experiments should be conducted over a period of years. An understanding of local ecological knowledge should be central to identifying additional variables to measure. Individuals who interact closely with plants tend to have good knowledge of ecological parameters, many of which (especially in the case of tropical plants) are not documented in the bioscientific literature. Semi-structured interviews on aspects of local ecological knowledge and the perceptions of harvest impacts should include plant harvesters as well as a range of community members who work in the environments in which the plants are gathered, such as hunters and firewood collectors. If medicinal plant harvesters note that for a given herb species, individuals harvested for their leaves have fewer flowers and fruit later in the season, these variables should be included in the study design, and the possible implications of these changes should be assessed.

At the population level, the impacts of harvest methods can be measured by empirically assessing population structure or dynamics, and by the use of matrix population models. For the latter, permanent plots must be established, and the survival, growth, and reproduction of individuals of all sizes monitored over time under different treatments. Matrix models can serve as important tools in analysis because hypothesized changes in practice can be modeled and their consequences evaluated. Cunningham (2001) provides detailed field methodologies for assessing the impacts of harvest on plant individuals and populations.

These kinds of comparative ecological experiments can yield significant results because high harvest rates under one resource management strategy may lead to population depletion, while the same rate of harvest using another technique may foster persistence. This is especially relevant for commercially harvested species on which many people's livelihoods depend, and for which over-exploitation is common. In these cases, decreasing harvest levels might simply not be realistic. Variation in sustainability might be due to subtle differences in management practices that often only become apparent through in-depth ethnographic

research. It is imperative to identify locally acceptable management practices that can increase the yield of particular plants while allowing populations of that species to persist.

Observational Approaches to Assessing Medicinal Plant Harvest Impacts

Manipulative experiments are often not feasible in the field, particularly when one is working with resources such as medicinal plants, which are under high harvest pressure. In these cases, observational experiments can substitute. For example, if it is not possible to work with local harvesters to experimentally simulate different bark harvest patterns on sets of individual trees (manipulative experiment), an alternative is to compare trees that are already being harvested under different strategies (observational strategy). It is important to ensure true replication in these experiments so that differences in harvesting strategies are not confounded with ecological and other differences between the sites. The experiment cannot be a comparison of trees from Site 1, which are harvested under strategy A, with trees from Site 2 harvested under strategy B. One needs to use a minimum of two sites for each strategy.

Observational experiments can be critical when the spatial or time scale of interest is large. For example, to assess the impacts of local management practices at the level of ecological communities and landscapes, observational experiments are usually required. How do harvest strategies for collecting medicinal plants affect plant community diversity and composition? This question is important because, while some harvest practices which are very effective in increasing populations of medicinal plant species might also sustain 'non-useful' species, other practices might result in the decline of some important but 'non-useful' species.

By comparing historical and current voucher specimens, Law and Salick (2005) showed that the heavily harvested medicinal plant, Himalayan snow lotus (*Saussuria laniceps*), has become significantly smaller over time. This has also been the case with American ginseng (*Panax quinquefolius*) (McGraw 2001). In these cases long-term harvesting of the largest individuals by harvesters appears to have led to selection for smaller plants, and therefore to decrease in plant size, similar to "logging down" in forests; and "fishing down" the food chain in fisheries. This has important conservation implications. If smaller-sized plants have lower survival and reproductive capacity, then the effects of both harvest and selection may decrease overall population viability.

Observational experiments are useful for evaluating the impacts of traditional social institutions on plant populations or communities, for example assessing medicinal plant diversity or density in sacred sites (e.g., Salick et al. 2007) or evaluating the effects of seasonal harvest prohibitions on plant community dynamics.

Ideally, both manipulative and observational approaches can be combined. For those medicinal plants that are heavily harvested, an observational approach may be used to compare the population growth rates in areas subject to different kinds of harvest strategies. Then experimental plots, perhaps arranged through an agreement with local community members or in some kind of protected area, can be used to experimentally test any important effects that appear to emerge from the observational experiments. This experimental complement is important because plant communities and landscapes commonly experience multiple uses and disturbances and so it can be difficult to tease out the impacts of any one management or harvesting practice in observational experiments. At the same time, observational experiments are critical if the plant in question is slow-growing, and the effects of harvest practices may take years to observe in an experimental setting.

Participatory Ecological Research Methods

Participatory ecological research offers an important, but still underutilized, tool for documenting the character and ecological consequences of local management practices. Researchers should factor in sufficient time early in their field schedules to ensure that collaborative ventures with local people are based on good rapport and mutually vested partners.

Participatory research involves community members in all stages of the research process, from the design of questions and coordination of methods to the execution of experiments and interpretation of the results. Local communities can identify the issues and questions of greatest importance to them. In cases in which Indigenous land rights are threatened, communities are interested in the documentation of their practices to mediate legal issues related to land tenure or the commercialization of species. In other cases, communities are concerned about the diminution of key cultural resources. Harvesters and researchers can work together to define specific research questions and hypotheses and identify the practices and variables that are the most important to measure. Local methods for monitoring the quality and quantity of resources can be used in conjunction with or instead of bioscientific methods. For example, Setty et al. (2008) showed that measures of amla (*Phyllanthus emblica* and *P. indofischerii*) fruit production obtained through observations by harvesters walking through the forest while conducting other activities can be as accurate as detailed bioscientific methods, which are much more time intensive. Collectors and researchers can quantitatively monitor aspects of vegetation dynamics in permanently marked plots. Local harvesters can lead activities such as recording the intensity, timing, and location of plant collection. Using GPS, collectors can map populations and individuals to document spatial patterns of harvest both within populations and across landscapes.

Such information is important for identifying patterns and intensities of harvest for heavily harvested and economically important species such as many medicinal plants and animals, developing quantitative datasets that reflect actual local practices, and monitoring the long-term health of populations and plant communities. Local monitoring is key for adaptive management strategies (Cunningham 2001; Setty et al. 2008; Ticktin et al. 2002).

Research objectives and methods that are designed in collaboration with communities can better address and respond to local interests and needs. From a conservation perspective, communities who are involved in the research, and have observed and carried out (formal or informal) experiments themselves, are more likely to put the results into practice.

REFERENCES

- ALCORN JB. Huastec noncrop resource management: implications for prehistoric rain forest management. *Hum Ecol* 1981;9:395–417.
- BEGOSSI A, HANAZAKI N, TAMASHIRO JY. Medicinal plants in the Atlantic Forest (Brazil): knowledge, use, and conservation. *Hum Ecol* 2002;30:281–299.
- BENNETT BC, BELL CR, BOULWARE RT. Geographic variation in alkaloid content of *Sanguinaria canadensis* (Papaveraceae). *Rhodora* 1990;92:57–69.
- BERKES F. Sacred ecology: traditional ecological knowledge and resource management, 2nd edn, New York: Routledge; 2008.
- BERNARD HR. Research methods in anthropology: qualitative and quantitative approaches. 4th ed. Walnut Creek (CA): Alta Mira Press; 2006.
- CANIAGO I, SIEBERT SF. Medicinal plant ecology, knowledge and conservation in Kalimantan, Indonesia. *Econ Bot* 1998;52:229–250.

- CASAS A, VASQUEZ M, VIVEROS JL, CABALLERO J. Plant management among the Nahua and the Mixtec in the Balsas river basin, Mexico: and ethnobiological approach to the study of plant domestication. *Hum Ecol* 1996; 24:455–479.
- CUNNINGHAM AB. Applied ethnobotany: people, wild plant use and conservation. London, and Sterling (VA): Earthscan; 2001.
- DAVIS A, WAGNER JR. Who knows? On the importance of identifying “experts” when researching Local ecological knowledge. *Hum Ecol* 2003;31:463–489.
- ETKIN NL. Edible medicines: an ethnopharmacology of food. Tucson: University of Arizona Press; 2006.
- ETKIN NL. Anthropological methods in ethnopharmacology. *J Ethnopharmacol* 1993;38:93–104.
- ETKIN NL. Cultural constructions of efficacy. In: VAN DER GEEST S, WHYTE SR, editors. The context of medicines in developing countries. Dordrecht: Kluwer; 1988. p 299–326.
- ETKIN NL. Benefit-sharing (BS?): hype or hope In: DHILLON SS, editor. *Proceedings of the International Conference on Medicinal Plants: access, use and benefit sharing in the light of the Convention on Biological Diversity*. Oslo: University of Oslo Press; in press.
- ETKIN NL, ELISABETSKY E. Seeking a transdisciplinary and culturally germane science: the future of Ethnopharmacology. *J Ethnopharmacol* 2005;100:23–26.
- ETKIN NL, ROSS PJ. Malaria, medicine and meals: a biobehavioral perspective. In: ROMANUCCI-ROSS L, MOERMAN DE, TANCREDDI LR, editors. The anthropology of medicine. 3rd ed. New York: Praeger; 1997. p 169–209.
- ETKIN NL, TICKTIN T. Integrating ethnographic and ecological perspectives for ethnopharmacology field research In: ELISABETSKY E, ETKIN NL, editors. UNESCO On-line Encyclopedia. 2005. Available at <http://www.eolss.net>.
- ETKIN N, TICKTIN T. Advancing an ethno-ecological perspective to integrate theory and method in ethnobotany. In: PAULINO DE ALBUQUERQUE U, editor. Research Developments in Ethnobotany. Pernambuco: Brazilian Society of Ethnobiology and Ethnoecology; 2009.
- FEIBERT EB, LANGENHEIM JH. Leaf resin variation in *Copaifera langsdorffii*: relation to irradiance and herbivory. *Phytochemistry* 1988;27:2527–2532.
- FORDYCE JA. The lethal plant defense paradox remains: inducible host-plant aristolochic acids and the growth and defense of the pipevine swallowtail. *Entomol Exp Appl* 2001;100:339–346.
- GANESHAIAH KN, SHAANKER RU, MURALI KS, et al. Extraction of non-timber forest products in the forest of Bilingiri Rangan Hills, India. 5: Influence of dispersal mode on species response to anthropogenic pressures. *Econ Bot* 1998;52:316–319.
- GAOUE O, TICKTIN T. Effects of bark and foliage harvest on *Khaya senegalensis* (Meliaceae) reproductive performance and morphology in Benin. *J Appl Ecol* 2008;45:31–40.
- GHIMIRE SK, McKEY D, AUMEERUDDY-THOMAS Y. Heterogeneity in ethnoecological knowledge and management of medicinal plants in the Himalayas of Nepal: implications for conservation. *Ecol Soc* 2004;9:6.
- GHIMIRE SK, GIMENEZ O, PRADEL R, McKEY D, AUMEERUDDY-THOMAS Y. Demographic variation and population viability in a threatened Himalayan medicinal and aromatic herb *Nardostachys grandiflora*: matrix modelling of harvesting effects in two contrasting habitats. *J Appl Ecol* 2008; 45:41–51.
- GIBSON D. Methods in comparative plant population ecology. Oxford: Oxford University Press; 2002.
- GOLLIN LX. Subtle and profound sensory attributes of medicinal plants among the Kenyah Leppo’ Ke of East Kalimantan, Borneo. *J Ethnobiol* 2004;24:173–201.
- GUEEDGE NM, ZUIDEMA PA, DURING H, FOAHOM B, LEJOLY J. Tree bark as a non-timber forest product: the effect of bark collection on population structure and dynamics of *Garcinia lucida* Vesque. *Forest Ecol Manag* 2007; 240:1–12.
- HANAZAKI N, CASTRO SOUZA V, RIBEIRO RODRIGUES R. Ethnobotany of rural people from the boundaries of Carlos Botelho State Park, São Paulo State, Brazil. *Acta Bot Brasil* 2006;20:899–909.
- HOFT M, VERPOORTE R, BECK E. Growth and alkaloid contents in leaves of *Tabernaemontana pachysiphon* Stapf (Apocynaceae) as influenced by light intensity, water and nutrient supply. *Oecologia* 1996;107:160–169.
- JARZOMSKI CM, STAMP NE, BOWERS MD. Effects of plant phenology, nutrients and herbivory on growth and defensive chemistry of plantain, *Plantago lanceolata*. *OIKOS* 2000;88:371–379.
- JOHNS T. The origins of human diet and medicine. Tucson: University of Arizona Press; 1996.
- JOHNS T, KOKWARO JO, KIMANANI EK. Herbal remedies of the Luo of Siaya District. *Econ Bot* 1990;44:369–381.
- JOYAL E. The palm has its time: an ethnoecology of *Sabal Uresana* in Sonora, Mexico. *Econ Bot* 1996;50:446–462.
- KYOSHABIRE M. Medicinal plants and herbalist preferences around Bwindi Impenetrable Forest, Uganda [MSc thesis]. Kampala: Makerere University; 1998.
- LAW L, SALICK J. Human-induced dwarfing of Himalayan snow lotus *Saussuria laniceps* (Asteraceae). *Proc Natl Acad Sci* 2005;102:10218–10220.
- LEWIS WH, ELVIN-LEWIS M. Obstetrical use of the parasitic fungus *Balansia cyperi* by Amazonian Jivaro women. *Econ Bot* 1990;44:131–133.
- LUOGA EJ, WITKOWSKI ETF, BALKWILL K. Differential utilization and ethnobotany of trees in Kitulughalo Forest Reserve and surrounding communal lands, Eastern Tanzania. *Econ Bot* 2000a;54:328–343.
- LUOGA EJ, WITKOWSKI ETF, BALKWILL K. Economics of charcoal production in Miombo woodlands of Eastern Tanzania: some hidden costs associated with commercialization of the resources. *Ecol Econ* 2000b;35:243–257.
- MARTIN GJ. Ethnobotany: a methods manual. People and plants conservation manuals. London: Chapman & Hall; 1995.
- MARTIN G, ET AL. The roots of trade: deciphering herbalist knowledge of medicinal plants in Marrakech. Presented

- at Society of Ethnobiology 30th Annual Conference, Berkeley, CA, March 29, 2007; unpublished.
- MCCUNE LM, JOHNS T. Antioxidant activity in medicinal plants associated with the symptoms of diabetes mellitus used by the indigenous peoples of the North American boreal forest. *J Ethnopharmacol* 2002;82:197–205.
- MCCUNE LM, JOHNS T. Antioxidant activity relates to plant part, life form and growing condition in some diabetes remedies. *J Ethnopharmacol* 2007;112:461–469.
- MCGRAW JB. Evidence for decline in stature of American ginseng plants from herbarium specimens. *Biol Conserv* 2001;98:25–32.
- McMILLEN HL. The roots of trade: local ecological knowledge of ethnomedicines from Tanga, Tanzania markets [PhD thesis]. Honolulu: University of Hawaii at Manoa; 2008.
- MOERMAN DE. Agreement and meaning: rethinking consensus analysis. *J Ethnopharmacol* 2007;112:451–460.
- MONTEIRO JM, PAULINO DE ALBUQUERQUE U, LINS-NETO E, ET AL. Use patterns and knowledge of medicinal species among two rural communities in Brazil's semi-arid northeastern region. *J Ethnopharmacol* 2006;105:173–186.
- MÜLLER J, BOUBACAR R, DAN GUIMBO I. Examining community consensus: including gender and age diversity in rural African ethnobotanical research and action (Boumba, Niger). *50th Annual Meeting of the Society for Economic Botany, Charleston, South Carolina*; 2009.
- MURALI KS, SHANKAR U, SHANKER RR, ET AL. Extraction of non-timber forest products in the forests of Biligiri Rangan Hills, India. 2: Impact of NTFP extraction on regeneration, population structure, and species composition. *Econ Bot* 1996;50:252–269.
- OSIER TL, LINDROTH RL. Effects of genotype, nutrient availability, and defoliation on aspen phytochemistry and insect performance. *J Chem Ecol* 2001;27:1289–1313.
- PEIFFER JM, BUTZ RJ. Assessing cultural and ecological variation in ethnobiological research: the importance of gender. *J Ethnobiol* 2005;25:240–278.
- RIJKERS T, OGBAZGHI W, WESSEL M, BONGERS F. The effect of tapping for frankincense on sexual reproduction in *Boswellia papyrifera*. *J Appl Ecol* 2006;43:1188–1195.
- SALICK J, AMEND A, ANDERSON D, ET AL. Tibetan sacred sites conserve old growth trees and cover in the eastern Himalayas. *Biodivers Conserv* 2007;16:693–706.
- SALMORE AK, HUNTER MD. Environmental and genotypic influences on isoquinoline alkaloid content in *Sanguinaria canadensis*. *J Chem Ecol* 2001;27:1729–1747.
- SAMPATH G, GURIB-FAKIM A, ETKIN NL. Fair and equitable benefit-sharing. In: SS DHILLON, editor. *Proceedings of the International Conference on Medicinal Plants: access, use and benefit sharing in the light of the Convention on Biological Diversity*. Oslo: University of Oslo Press; in press.
- SCHIPPMAN U, LEAMAN D, CUNNINGHAM AB. Impact of cultivation and gathering of medicinal plants on biodiversity: global trends and issues. In: Biodiversity and the ecosystem approach in agriculture, forestry and fisheries. Rome: FAO; 2002.
- SETTY S, BAWA KS, TICKTIN T, MADEGOWDA G. Evaluation of a participatory monitoring system for non-timber forest products: the case of amla (*Phyllanthus spp.*) fruit harvest by indigenous Soliga communities in South India. *Ecol Soc* 2008;13:19.
- SHEPARD GH JR. A sensory ecology of medicinal plant therapy in two Amazonian societies. *Amer Anthropol* 2004;106:252–266.
- SILLITOE P. Ethnobiology and applied anthropology: rapprochement of the academic with the practical. In: ELLEN R, editor. *Ethnobiology and the science of humankind*. Oxford: Blackwell Publishing; 2006. p 147–175.
- STEPP JR, MOERMAN D. The importance of weeds in ethnopharmacology. *J Ethnopharmacol* 2001;75:19–23.
- TICKTIN T. The ecological consequences of NTFP harvest: a review. *J Appl Ecol* 2004;41:11–21.
- TICKTIN T, DE LA PEÑA G, ILLSLEY C, ET AL. Participatory ethnoecological research for conservation: lessons from case-studies in Mesoamerica. In: STEPP JT, WYNDHAM FW, ZARGER R, editors. *Ethnobiology and biocultural diversity: Proceedings of the Seventh International Society for Ethnobiology*. Athens: University of Georgia Press; 2002. 575–584.
- TICKTIN T, JOHNS T. Chinanteco management of *Aechmea magdalenae* (Bromeliaceae): implications for the use of TEK and TRM in management plans. *Econ Bot* 2002;56:43–57.
- TRAGER L. Minimum data sets in the study of exchange and distribution. In: MORAN EF, editor. *The comparative analysis of human societies: toward collection and reporting*. Boulder (CO): Lynne Rienner Publishers; 1995. p 75–96.
- TURNER NM, IGNACE B, IGNACE R. Traditional ecological knowledge and wisdom of aboriginal people in British Columbia. *Ecol Appl* 2000;10:1275–1287.
- TROTTER RT, SCHENSUL JJ. Methods in applied anthropology. In: BERNARD HR, editor. *Handbook of methods in cultural anthropology*. Walnut Creek (CA): Alta Mira Press; 1998. p 691–735.
- VAN DER GEEST S, REYNOLDS WHYTE S, HARDON A. The anthropology of pharmaceuticals: a biographical approach. *Annu Rev Anthropol* 1996;25:153–78.
- VOEKS RA. Tropical forest healers and habitat preference. *Econ Bot* 1996;50:381–400.
- VOEKS RA, LEONY A. Forgetting the forest: assessing medicinal plant erosion in Eastern Brazil. *Econ Bot* 2004;58(Suppl):294–306.
- WILLIAMS VL. The design of a risk assessment model to determine the impact of the herbal medicine trade on the Witwatersrand on resources of indigenous plant species [PhD dissertation]. Johannesburg: School for Animal, Plant and Environmental Sciences, University of Witwatersrand; 2007.

Chapter 15

Assessments of Indigenous Peoples' Traditional Food and Nutrition Systems

LETITIA M. McCUNE

BotanyDoc Education and Consulting Services, Tucson, Arizona

HARRIET V. KUHNLEIN

Centre for Indigenous Peoples' Nutrition and Environment, McGill University, Montreal, Quebec, Canada

METHODS	250
STEP 1. THE TEAM AND BACKGROUND INFORMATION	251
STEP 2. TRADITIONAL FOOD LISTS	253
STEP 3. INDIVIDUAL INTERVIEWS FOR FOOD USE PATTERNS	256
STEP 4. SCIENTIFIC DATA COLLECTION FROM SPECIES	258
STEP 5. COMMUNITY DISCUSSIONS, PRESENTATIONS/REPORTS, AND OBJECTIVES TO USE LOCAL FOOD IN AN INTERVENTION TO IMPROVE HEALTH	259
RESULTS	260
THE SOUTHWESTERN UNITED STATES	260
THE CANADIAN ARCTIC	261
INTERNATIONAL INDIGENOUS PEOPLES' CASE STUDIES	262
REFLECTIONS	263
REFERENCES	264

The food systems of Indigenous peoples offer important information for understanding the functional aspects of the culture, environment, and health of the people using them. As well as the universally recognized contribution that food makes to physical health, many Indigenous societies recognize the central aspects of food to mental, emotional, and spiritual health. An environment that has remained reasonably intact for people dwelling there for

many generations can be assumed to provide at least the minimum of food and food diversity to support good health and social function. In this chapter we focus on the food systems of those Indigenous peoples still dwelling within rural areas that can provide a major portion of dietary energy and essential nutrients as traditional food from the local environment. While many of the methods described can be useful in any areas and with any group of people, the focus here is working within a defined culture in a specific environment or homeland to understand the nuances of food resources available and used locally.

With the encroachment of industrial food resources into all corners of the world it is useful to be able to assess the interplay and interdigitation of traditional food and market food in the daily and annual diets of community members. Change in Indigenous peoples' food systems is universal; developing an awareness of change and the factors driving it are among the first important considerations in the assessment process of a food system within a particular culture (Kuhnlein and Receveur 1996). Also important are recognition of the actual self-identification by the culture under review (see Bartlett et al. 2007) and understanding of constraints in the food environment (Kuhnlein and Receveur 1996).

Goals for traditional food research with Indigenous peoples must be set in collaboration with the Indigenous communities contributing to the research process. This means discussion and agreement on the principles of the Declaration of the Rights of Indigenous Peoples (<http://www.iwgia.org/sw248.asp>) that touch on food resources, and how research can contribute to policies that recognize the right to food (Damman et al. 2008). Advances in processes that protect the rights of Indigenous peoples in health research have been outlined by the Canadian Institutes of Health Research (<http://www.cihr-irsc.gc.ca/e/29339.html>); see also Bannister and Hardison 2011; Gilmore and Eshbaugh 2011).

The Centre for Indigenous Peoples' Nutrition and Environment (CINE) was created at McGill University in Montreal, Canada, as a resource to assist Indigenous peoples with research and understanding of food systems. With leadership from Indigenous organizations in Canada and academic-based researchers, advances in methodology for food system assessments have contributed to food and nutrition research and understanding the impact of food biodiversity for Indigenous peoples in many parts of the world (<http://www.mcgill.ca/cine> and <http://indigenousnutrition.org/>). This chapter largely draws on the research conducted through CINE.

METHODS

Methods described here are based on a document created by CINE researchers with international case studies of Indigenous peoples in Asia (<http://www.mcgill.ca/files/cine/manual.pdf>). Five general steps are involved in the documentation of traditional food systems.

- 1 The research team needs to be assembled and background data gathered. A crucial aspect of the research team is leadership members of the intended community who have expressed a desire for the research and will directly benefit from it.
- 2 Acquisition of food list information.
- 3 Description of food use patterns.
- 4 Gathering of taxonomic, ethnoecological, and nutrient data for animal and plant species in the food list.
- 5 Review of the information with the community and any necessary procedures to ensure the health of the community and the continued use of the traditional food system.

	Week							
	1	2	3	4	5	6	7	8
Set-up and Background Data	■	■						
Community Food System Data Tables	■	■	■	■	■	■	■	■
Key-informant Interviews/Focus Groups	■	■		■	■		■	■
Community Traditional Food List	■	■						
Market Survey			■	■				
Food Sampling and Laboratory Analysis			■	■	■	■	■	■
Community Discussions	■							■
Interpretation and Report							■	■
Planning to Conduct Intervention								■

Figure 15.1 Timeline schematic as an example plan. Courtesy of H.V. Kuhnlein.

The gathering and reporting of data with the community can be undertaken in about eight weeks, if progress is consistent (e.g., Fig. 15.1; Kuhnlein et al. 2006c). Data collection may need to be repeated at different times of the year to accommodate the seasonality of different foods. This timeframe is for about 30 unique foods to be analyzed for key nutrients of interest within six weeks. The length of time the chosen laboratory has to devote to the project is variable, but it is reasonable to aim for completion within this time period.

Step 1. The Team and Background Information

A research management team should be compiled, including a specialist trained in nutrition, the local leaders of the community, an anthropologist or cultural specialist of the area, a laboratory analyst, and a food composition database and dietary analysis specialist. These members should be consulted early in the research process to determine details of the research plan. It often also helps to have an herbarium specialist and local environmental specialist to ensure appropriate methods of sampling and to determine environmental constraints. The eight-week timeframe for data collection in the community depends on having a research manager and two field assistants. In addition the use of a translator (if needed), the training of community members in research methods, and the use of a good facilitator in the focus groups may increase the number of staff members on the project.

Once it has been established that the proposed research is a priority for the community, a good participatory relationship needs to exist. Participatory agreements should be in place as described in chapters in this textbook or as found at the CINE and World Health Organization (WHO) websites. Issues that must be addressed in the research collaboration include: funding, ethics and consent of participants, research partnerships for mutual benefit, intellectual property rights, respect and understanding for diversity by engaging local translators and interviewers, advice from local communities, capacity building for the research

process, transparency in resource use, and effective management and evaluation of the research (CIHR 2007; Sims and Kuhnlein 2008; UNPFII 2007).

Community trust is imperative to ensure participation and accurate and complete documentation of the traditional food system. Often food intake includes sensitive subjects such as ritual feasting, medicinal teas, and sacred plant ingestion. In many Indigenous cultures, and some could argue in Western society's functional foods, there is a blurry line separating medicine and food (Johns 1990). Among the 35 different plant species used for symptoms associated with diabetes by the Indigenous peoples of the Canadian boreal forest 60% were also used as beverages or tonics and 63% were also used as food (McCune and Johns 2003). Etkin and Ross (1982) also illustrate this in their study of the Hausa of northern Nigeria, with many examples of medicines used as foods in the context of gastrointestinal disease. Components that could be considered medicinal in food include, but are not limited to, tannins (which relieve diarrhea), vermifuge agents (as in condiments like epazote, *Chenopodium ambrosioides*), antibacterial agents (as in capsaicin in chili peppers), and anti-oxidants (as in vitamins which are preventative of cancer, heart disease, etc.). One should be aware of potential nutrients ingested in medicinal preparations, and potential components of the food system that could alleviate medical conditions in the community. Care should be taken to respect the intellectual property rights of the community and of those individuals knowledgeable about the medicinal properties of species in their local habitat. It is important that it is understood that the end results will be disseminated to the community along with other benefits of the research, such as the training of community members in research methodology, the disbursement of medical supplies, health literature for the local school, or other agreed methods of compensation.

Informed consent must be secured (see guidelines in Gilmore and Eshbaugh 2011). Suitable consent forms typically consist of: statements of privacy (no information will be publicly linked to a name); that they can drop out of the project at any time without fear of recrimination; the risks if any; a summary of the project; and the leaders' names and contact information. If forms cannot be used, there should be documentation of each individual's verbal consent associated with the same information that would have been on a form. Members of the research management team associated with a university should have access to a Human Subjects Protection Program either through an internal ethics review board or granting agencies. Although often tailored to medical or drug evaluation, these training programs are relevant to nutrition projects. At all times the research team should be respectful of all statements made in the data collection process, respectful of the time of the volunteers, and protective of the volunteers' confidentiality of statements and personal information. All notes should be located in a secure place as some will consider the information given as private. Photographic documentation is an asset, but it should be ensured that the community as a whole is comfortable with photography, and that methods are put in place for individual authorization to use photographs for the intended purpose. In the published literature there are examples of acknowledgement of community contributors (e.g., Kuhnlein and Turner 1991; Turner and Kuhnlein 1983) and the association of names with knowledge (e.g., Turner et al. 1983). These would be in addition to agreements with the community, with informed consent, and with the knowledge of the leaders of the community.

Background information should be gathered in line with the documented request of the community for the intended research. This involves collecting known and/or published data on the geographical area and environmental threats, the types of plants and animals, any known nutrient analyses of the local plants and animals, any known nutritional information of the population of the area (including nutrition surveillance or development program

reports), and the history of the Indigenous community's language and cultural background. Ethnographies and migration history in the area and the patterns of annual migration (perhaps for employment) into other areas (such as agricultural or urban areas) should be reviewed to facilitate the research plan. Information should also be collected on the community's infrastructure, general family structure, access to health care, occupational profile, and the uses of traditional and Western medicine. Information on general food production practices and access to food markets should be collected. This information will give a framework for developing focus group questions and discussions for Step 2.

Step 2. Traditional Food Lists

Traditional food systems often include 70–100 species or more. Gathering information from a few key informants in a freelist format will begin the identification process. Recipes are not the focus at this stage, but rather the names of plants and animals and their parts and life cycle stages used for food. The information from these key informants will be solidified and augmented through focus group information (6–10 individuals). These focus groups can use food groupings (such as fruits, vegetables, etc.) to help trigger information (see Fig. 15.2). A seasonal calendar can also be used for identifying when each food is available. Food usages and preferences for mothers and children can also be gathered during these focus groups, as well as information on casual foods by age and gender that could depend on location and activities. Usual portion sizes used by age and gender are key information for dietary analysis. Care should be taken to interview a broad spectrum of members of the community in relation to gender and age as there are, inevitably, significant differences in food consumption patterns. Potential examples (in addition to obvious differences in quantity, spiciness, etc.) include extra consumption of meat by male members of the community during a hunt, reservation of organ meats for the elderly, or the self-sacrifice of women's food to children in times of food deprivation in the area. Methods of locating key informants and interviewing techniques can be found further in Blum et al. (1997), Kuhnlein and Pelto (1997) and Kuhnlein et al. (2006c).



Figure 15.2 Karen community food list workshop. Photograph from H.V. Kuhnlein.

Any plant species or local food sources that are no longer used or are limited in use or availability should be determined, as well as the reasons why, as far as possible. Elders or the younger generation may have rejected certain foods for taste or cultural reasons and could be sources for this information. Additional information may be gathered from those living on the outskirts of the community or those with more limited access to market items. Reasons for a drop in the use of a food can be varied, including, but not limited to, pollution, government regulations restricting use or access, resource depletion, movement of the community away from the food source, building on the usual collection site, and so on. It is imperative that these food sources no longer accessed are documented, as they may have been a source of nutrients for former generations. They may serve as a potential source of nutrients for the future and/or a means of identifying what may be lacking in the current food system. As these species may be more difficult to collect, information can be gathered with pictures, as well as descriptive narratives about appearance, location, harvest times, and preparation. Included in this list are those species considered for consumption during times of drought or as "famine foods."

Market and vendor data should be collected, especially for those foods likely to be high in nutrients and/or available during seasons of little hunting/gathering and/or agriculture. They may also be a source of nutrients as foods popular for children. Variations in cost and availability throughout the year should also be noted. As with other food source documentation, care should be taken to properly identify the part used (leaves versus roots/tubers, liver or bone, etc.). Different parts can have differences in antioxidants (McCune and Johns 2007) as well as in other nutrients such that assumptions should not be made about the part consumed. For example: the white of a lemon rind, and sometimes the peel, is at times consumed by Indigenous youth of the Southwestern U.S., thus adding antioxidants and anticancer components to the diet (Crowell and Gould 1994). Varietal differences in species are also important: white potatoes have different nutrients from yellow potatoes, red carrots have different levels of carotene from orange carrots, and red palm oil has a vastly different content of pro-vitamin A from clear corn cooking oil. The addition of condiments, spices, or greens may also be in amounts uncharacteristic to the interviewer and could be a considerable source of nutrients.

Observations or documentation of food preparation methods and techniques are necessary to identify added minerals or other nutrients in the diet (e.g., Fig. 15.3). The addition of water, or procedures that increase nutrient absorption or availability must be documented (Kuhnlein 2000). Some examples are: (1) oils consumed with orange or red food items can increase the bioavailability of lipid-soluble vitamins or carotenoids including lycopene (Unlu et al. 2005); (2) sources of vitamin C consumed with iron can increase iron absorption; (3) condiments, salts, or ash additions can add minerals (Kuhnlein 1980); and (4) the addition of conifer needles or other greens high in acid to pit-cooking can increase the availability of sugars in the consumed foods (Crawford and Yip 2007). Ambient soil content in the area can also affect the mineral or vitamin content of the plants harvested (Ferland and Sadowski 1992; Mercadante and Rodriguez-Amaya 1991) potentially causing a variance in nutrients as compared to standardized nutrient databases.

With the foregoing information, food data tables can be compiled. Costs, preparation (part used, boil/roast/dry, etc.), personal preferences, and quantities harvested/available to the community (based on season and market availability) should be documented. Typical data collection forms can be found at <http://www.mcgill.ca/files/cine/manual.pdf> (the document can be downloaded in sections, and example forms downloaded separately).

Searches need to be conducted to gather information on the nutrients available in those species that already exist in food databases in the public and scientific literature. Care should



Figure 15.3 Pohnpeian fish traditionally prepared with fermented breadfruit balls. Photograph courtesy of kpstudios. (See color insert.)

be taken to properly identify the variety of the species used as compared to the variety reported in the literature. If there is a difference, new nutrient data on the unanalyzed variety may need to be gathered. Nutrient content can vary based on size, maturity, color, part collected and consumed, and so on. Information on the nutrients known in many traditionally used plants in Canada can be found in Kuhnlein and Turner's (1991) book on traditional plant foods of Canadian Indigenous peoples, Arnason et al. (1981), the Canadian Nutrient File (<http://www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/index-eng.php>), and CINE's database on native foods. Databases on unique foods of other localities include CINE's database in the website above, the USDA Ethnic Foods database (<http://www.nal.usda.gov/fnic/foodcomp/Data/SR18/reports/sr18fg35.pdf>), and the USDA nutrient data laboratory database for standard reference (<http://www.ars.usda.gov/Services/docs.htm?docid=8964>).

Ideally the researchers at this point will have systematically collected information on: freelists of species, groupings of species, seasonality and preferred harvesting months (see Fig. 15.4), child/adult preferences (may be combined with other data), market products/availability, little-used species, and individual food and nutrient data tables. The research team may decide to focus on a short list of key food items for more intensive study. For example, a short list of key micronutrient foods (25–30 species/varieties) can be compiled using the information gathered to this point from the individual food descriptions, use, preferences, and known nutrient contents. Micronutrient-rich foods for this list that are likely to be high (for example) in iron (animal products and dark leafy greens), vitamin A (yellow and orange fruits and vegetables) or vitamin C (fruits and greens), are widely acceptable to the community and are relatively accessible at least for part of the year (greater than one month). A food list for further study could have foods that have little or incomplete nutrient and general documentation in public and scientific literature. Depending on the research interest, shortlists could be developed for complementary foods for infants, for unique animal sources, or plant foods in a particular category, and so on. Information from the food patterns of Step 3 will help solidify these short lists.



Figure 15.4 Salome Yesudas separating food seeds by season in the Zaheerabad Dalit area, India. Photograph courtesy of kpstudios. (See color insert.)

Step 3. Individual Interviews for Food Use Patterns

Interviews targeting food use patterns can be conducted during the same span of time as Step 2 and will give a good picture of the average consumption patterns of the community. If an intervention is anticipated, statistical power needs to be considered at this point to determine the appropriate number of respondents. Often 100 respondents will fill the statistical requirement. The community leaders should be consulted for general food pattern differences (and numbers) within the community (i.e., those in outskirts, those more likely to use traditional foods, those who rely heavily on market products, etc.). Random selection should then be conducted to determine respondents from these groups. The complex process of dietary analysis is most reliably completed with the cooperation of a professional dietary analyst—usually located in government or university settings. Key methods include the 24-hour recall and the food frequency questionnaire. Procedures and forms for these can be found in most nutrition textbooks. These methods are described briefly here.

- 1 The 24-hour recall documents the average consumption pattern of a group, but not the usual pattern of an individual, whose intake can vary day to day. Two or more recalls are needed on non-consecutive days of one week. Seasonality should be considered and series of recalls possibly done, especially with those more likely to consume traditional foods. The recall also gathers portion size information so that calculations can be done with food composition data on the nutrient intake of the group. The forms consist of documenting whether or not it was a usual day (not sick, not a holiday, etc.) and columns headed with the time of day (start when waking in the morning), food item, ingredients, general preparation method, source of food, amount consumed, food code (developed from source list), weight

in grams, and comments. Information should be available on the regular meal patterns of the community (two meals per day?) and any differences in meal patterns by age and gender. Most standardized recall forms have provision to take a “second pass” at recall for usually missed items such as between-meal drinks and snacks, additions to beverages and “spreads” on bread products.

- 2 The food frequency interview can be completed at the same time as the recalls and provides data related to how often traditional food items are consumed that season, with a possible focus on shortlisted key items. The data form should not only state the name of the individual (to be later coded numerically), but also the community name for the season and the associated months. Columns should be included for listing the traditional food name, the number of times it is consumed (per day, week, or month) and the range of typical portion sizes. In addition an area is often included for a team member to rank the foods according to amounts of vitamin A, vitamin C and iron, and/or other nutrients. Portion size is difficult to capture quantitatively, as it is variable. Information on mean portion size can be gleaned from recall data. Recalls of purchases can be useful also, including price of portions purchased.
- 3 The card sort method helps to understand the food system by giving cultural characteristics to the traditional foods. Cards are created from index cards with numbers on one side and a picture or drawing of the food on the other. Usually a maximum of 30 items can be considered in one card sort. Food items are grouped in a game-like setting and tabulated on a data form which typically includes a column for listing the numbers of the foods for each of the groupings done in a card sort and a column for the characteristics associated with that group (see Fig. 15.5). Data collection can be divided into more than one card sort. For more information see Blum et al. (1997).



Figure 15.5 Professor Sakorn administering the card sort exercise with Karen, Thailand. Photograph from H.V. Kuhnlein.

Additional data can be completed for general health characteristics of individuals (for example, height, weight, hair condition, paleness of eyelid, general eyesight, and mouth sores), infant food history (breastfeeding history, other milks, introduction of other foods, etc. up to two years of age), taste scores and ranks for the individual food items per interviewer and child, and attributes associated with the foods especially important in infant and child care. Summaries can then be created for the card sort information from the community as well as for each individual food item for the attributes associated with each food species.

Step 4. Scientific Data Collection from Species

Nutrient data is needed on the foods identified in Step 3 in order to complete the dietary analysis of that step. If nutrient data and tables cannot be found in the scientific literature, or if published material refers to types and varieties different from those found locally, then laboratory analyses of certain foods and their components should be considered. Local vegetables, for instance, are often more nutrient dense than commercial varieties. Foods to be analyzed and documented with specimens should be carefully considered from the food list, and the list shown to the local community leaders for confirmation of their importance. In considering costs in time and money, these items should be those missing accurate or complete information in the literature. Care should be taken to ensure proper scientific identification and nomenclature, as analyses of improperly identified foods are a wasted effort and difficult to publish in the scientific literature. Plant foods should usually be identified via voucher specimens at a herbarium (Turner and Nolan 2011). Pictures and descriptions of the local environment where the food is located or grown are valuable. Animal information can be gathered from photographs of the habitat of the animals, specimen photographs of the intact animal before kitchen preparation, and so on (see Hunn 2011).

The first step in analysis is to identify a good food analysis laboratory, ideally not too distant from the sample collection site. The laboratory should be scrutinized for good practices that include the ability to generate an accurate result repeatedly from the same sample. Internal standards from reliable sources should be used within each experiment and between experiments. The laboratory should have clean glassware, well trained staff, daily record keeping (lab notebooks) and well calibrated equipment. Costs of food analysis can vary by laboratory but could be in the range of US\$190 (Thailand national laboratory 2001 prices) to get one sample analyzed for proximate composition (protein, moisture, fat, ash), dietary fiber, retinol, carotene, folic acid, vitamin C, iron, and zinc.

Separate samples are gathered from those used for identification purposes. Since samples are for nutrient analysis they should not be pressed, dried, or exposed to excess heat or other conditions that could cause spoilage or loss of nutrients. Vitamin C, for instance, can disappear quite rapidly from a drying specimen. Sample amounts should be 100–500 g, clean, without adhering moisture or soil and in the form typically gathered as food (correct part and not unripe or spoiled). Each sample should have a label attached that includes the name, place, date, person collecting, and the size of the sample. Sample numbers should also be included and correspond to numbers already known by the laboratory. A field notebook should also include this information for later confirmation. Samples can be gathered in clean ziplock bags, placed in coolers with ice, and transported quickly to where they can be frozen until analysis. If cooked samples are to be included (if that is the usual preparation for consumption) cooking will help reduce spoilage during transport.

Careful documentation needs to be done to include the amount of water added to the uncooked item (also measured) or time/temperature of roasting, baking, and so on. No additional ingredients should be included during cooking, as this makes nutrient identification by species impossible.

The AOAC (Association of Official Analytical Chemists) has a standard reference for analysis methods. Analytical methods can also be found at the Canadian internet site <http://www.hc-sc.gc.ca/fn-an/res-rech/analy-meth/chem/index-eng.php> and recent articles using current methods of analysis can be found in the *Journal of Food Composition and Analysis*.

Wells or water sources used by the community should be considered as a potential source of minerals, including iron and calcium, and therefore possibly analyzed. The amount of water consumed by individuals (this includes uses as teas, mixed beverages, soups, etc.), should be documented in the 24-hour recall to capture this potential source of nutrients. Contaminants in water can also be enumerated in this way. Also remember that cookware may provide metal nutrients or may react with nutrient chemicals in foods; preparation methods and cooking utensils should be stated on the sample collection form.

In areas of the world associated with increased pollutants, whether from local or global sources, analyses of foods may be needed to reveal contaminants. Care must be used in any determination of associated risk and benefit of traditional foods. Detailed analysis in combination with all the above methods would be required to determine the dose of any particular contaminant as well as associated variations of location and individual food species. Market foods are often proven to be inferior nutrient sources in comparison to local foods (Jensen et al. 1997). Traditional foods may be dense in nutrients and fulfill cultural, spiritual and other roles in the traditional society. For further discussion see Kuhnlein et al. (2005) and Oostdam et al. (2005).

Step 5. Community Discussions, Presentations/Reports, and Objectives to Use Local Food in an Intervention to Improve Health

A review of the data collected should be done in a meeting which includes the key community members of the research team. This is important to identify any significant errors in feasibility from the community perspective. A shortlist of foods (10–20 items) could be evaluated for relevance and potential to improve the health of the community based on availability, taste preference, and so on as gathered in Steps 1–4. Following this meeting, key informants from the community and/or other experts should discuss the environmental advantages, disadvantages, or constraints to increasing consumption of any of the identified food items for promotion.

A community meeting to present the findings from Steps 1–5 can provide feedback as to what issues are perceived for the health of the community, the roles of the members, and the role of the foods. Ample time should be given for comments and questions from the key members and leaders of the community. It also helps to enlist the help of the local members of the research team in making decisions about the best presentation style and methods.

Following this general meeting, smaller meetings can be organized with the leaders of the community to determine if intervention is desired using the gathered information. If there is to be a change or intervention using the traditional food system to improve

the health of the community, decisions need to be made about who would be the target group and who and what is needed to support the effort. Subsequent meetings with important target groups (such as mothers and children), supporting groups (such as fathers, elder women, typical hunters/gatherers), community leaders (including church and school), and political figures will ensure the most understanding, advice, and support for the project. If an intervention using the traditional food system is desired by the community, adequate record keeping of suggested processes will help to ensure success. Information on intervention methods and strategies can be found in the guidelines in Kuhnlein et al. (2006a).

RESULTS

In this section we summarize some studies that have used the methods described above to document the traditional food systems of Indigenous peoples. We illustrate the health-giving properties of the traditional food sources as well as the associated food systems. As concerns rise over the increased incidence of obesity, diabetes, and disease with the increase in use of industrialized foods and the “Western lifestyle,” these studies contribute to identification of ways to restore healthy local foods in diets of Indigenous peoples. (Many of these studies are the result of concerns and research questions raised by Indigenous peoples with the academic partners of CINE.)

The Southwestern United States

The loss of traditional food systems has been documented in the desert southwest of the USA. With the approval of the Hopi Tribal Council and parents of schoolchildren, research from the University of California at Berkeley was performed in the 1970s to document the traditional foods of the Hopi. Kuhnlein and Calloway (1977) documented information from dietary recalls of schoolchildren and women and conducted traditional food analyses. Traditional foods consumed in the past (known from literature searches) as well as the then current period were studied. The consumption of traditional greens and other plant foods diminished strikingly. Further analysis of some traditional foods found good sources of minerals with the use of culinary ash. This led to studies on analyses of Indigenous salts including culinary ash (Kuhnlein 1980; Kuhnlein et al. 1979). This work, among others, resulted in the recognition of the health potential of blue corn, which is often processed with ash in cooking. The anthocyanins (health promoting antioxidants) present in the blue corn are heightened in color with the increased pH caused by the ash addition as well as an associated increase in calcium and iron in this food source (Kuhnlein 2000).

Diabetes has reached epidemic proportions among Indigenous peoples as they reduce use of their traditional food systems with the introduction of food from industrialized societies (Diamond 1992; Young 1994). For the Indigenous peoples of the southwestern states, diabetes rates are documented as among the highest in the world at over 50% of Akimel O’odham (Pima) between the ages of 30 and 65 and 33% of all adult American Indians in southern Arizona (Centers for Disease Control and Prevention, 2011; Lillioja 1996). While studies are ongoing on genetic influences on diabetes, research by Ravussin et al. (1994) illustrates the importance of the traditional lifestyle (including diet) by comparing people of Akimel O’odham heritage in Arizona with those living more traditionally in Maycoba, Sonora, Mexico. Food frequency data demonstrated lower amounts of fat and

higher fiber intakes in the more traditional diet and suggested reasons for the lower incidence of diabetes in the Akimel O'odham of Mexico. Studies of traditional diets of the Tohono O'odham (Papago) and Akimel O'odham cultures (Smith et al. 1994; Williams et al. 2001) can be augmented by those of Ross (1944) and others (e.g., Brand et al. 1990; Nabhan et al. 1980; Teufel 1996), which document nutrient analyses of cacti including prickly pear (*Opuntia* spp.), mesquite (*Prosopis* spp.), and traditional varieties of beans. Many desert foods have high levels of soluble fiber, a property known to slow digestion and to be of benefit to those prone to diabetes. Prickly pear pads and fruit have been shown to have hypoglycemic properties (Stintzing and Carle 2005) as has mesquite, a sweet legume often ground into flour (Brand et al. 1990). The loss of use of these traditional foods with the introduction of wheat, commercial maize and its products, and other industrial foods has changed the dynamics of the food system of desert peoples. With changing activity and lifestyle patterns this has resulted in increased diabetes. Organizations such as TOCA (Tohono O'odham Community Action) are working to re-introduce many of the traditional foods of the culture's original food system to help stem the tide of diabetes.

The Canadian Arctic

Concerns about contamination of the environment led to analyses of many food sources of the Arctic in the 1990s. The study by Morrison et al. (1995) with the Sahtú Dene/Métis use of traditional and market food is an example of the use of many of the methods outlined above. Traditional food frequency data, along with the charting of seasonal variations, revealed a high percentage of use of mammals followed by fish, birds, and berries. The 20 most consumed items of traditional foods and market foods were ranked on average daily intake. Conclusions were that the increase in use in market foods was decreasing the use of nutrient-dense traditional components in the diet. Dietary analysis showed that purchased foods were of inferior average nutritional quality. Further articles on the benefits of traditional food consumption by the Dene/Métis, including that of Receveur and Kuhnlein (1998), showed associated attributes of traditional foods (see Kuhnlein and Chan 2000; Kuhnlein et al. 2005).

Food analysis, 24-hour recalls, and use frequency interviews show that traditional animal foods account for significant sources of energy and nutrients in Arctic diets. Therefore, displacing them by market products often high in fats and sugars is nutritionally undesirable (Kuhnlein and Receveur 2007). Despite a seeming lack of plant material that could be typical sources of vitamin C, analyses of traditional food of the Inuit revealed many foods rich in vitamin C (Fediuk et al. 2002). Additional Arctic food samples and dietary interview data gathered over several years form a substantial database in CINE, demonstrating high amounts of many nutrients including vitamins A, D and E and several B vitamins in traditional diets (Hidiroglou et al. 2008; Kuhnlein et al. 2006b). Separation of animal parts for the analysis of the fats and organ meats proved that Arctic food sources provide high levels of many vitamins. It was also shown that the times of the year when traditional foods were more frequently consumed were when intakes of these vitamins were higher. Conclusions from these studies indicate that the nutrient benefits likely outweigh the risks of potential low levels of contamination from consuming animals high in the food chain. These studies, as well as a study on dietary adequacy in three Canadian Arctic cultural groups (Kuhnlein et al. 2007), have emphasized the importance of continued use of traditional foods to protect the Dene/Métis, Yukon First Nations, and Inuit from nutrient inadequacy.

International Indigenous Peoples' Case Studies

CINE and associated research partners have documented traditional food systems of 12 community areas of Indigenous peoples located around the world. The objectives of this combined work are to preserve the knowledge of these systems and the associated use of species, and to call attention to the potential of traditional foods to provide nutrients and promote health. Objectives are also to identify the importance of conservation of associated lands for food security and nutrition of those using the local foods. This is especially important in communities living in poverty in marginalized areas. Low income and little access to quality market foods are often associated with limited intake of foods of nutritional quality. This need not be the case if biodiverse traditional foods, dense in nutrients, can be produced, harvested, and utilized.

The 12 case study communities were purposely chosen for location in diverse regions of the world. These include: Canada (Baffin Island Inuit, Gwich'in, Nuxalk); Colombia (Ingano); Federated States of Micronesia (Pohnpei); India (Bhil, Dalit); Japan (Ainu); Kenya (Maasai); Nigeria (Igbo); Peru (Awajún/Aguaruna); and Thailand (Karen) (see map in Fig. 15.6).

The research with the Dalit in Zaheerabad, South India, revealed chronic energy deficiency (CED) of 58% among Dalit mothers and incidences of vitamin A deficiency (Schmid et al. 2006). Results indicate a reverse association of traditional food consumption and clinical vitamin A deficiency and CED. Conclusions were that traditional food items should be encouraged and potentially used in local health promotion activities. Schmid et al. (2007) also investigated the comparison of villages with and without an intervention of supplemental traditional food provided through a community-based food security

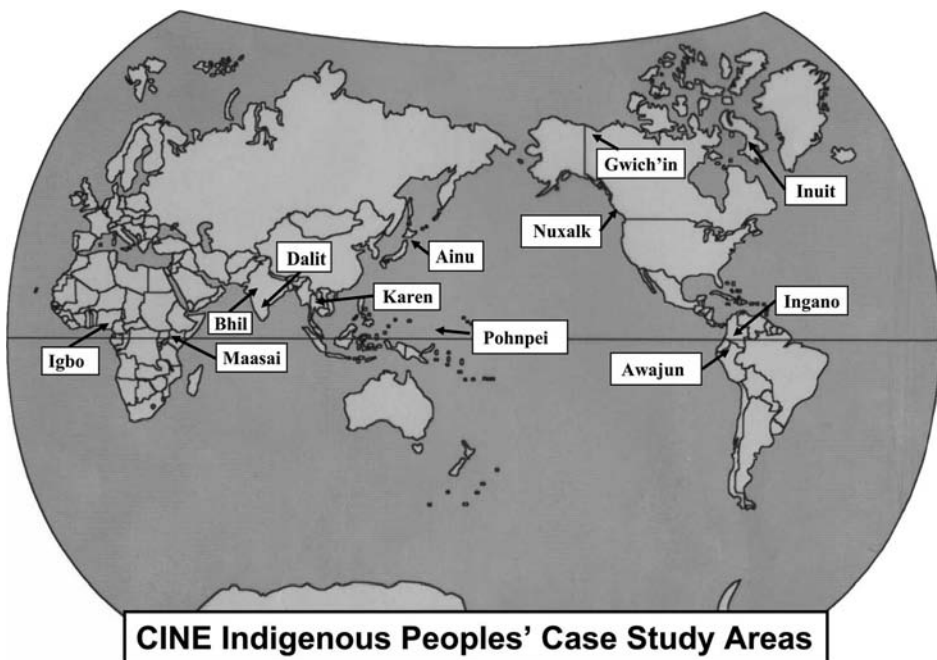


Figure 15.6 Map of 12 case study communities. Courtesy of H.V. Kuhnlein.

system. The mothers with young children in the intervention villages had higher dietary levels of energy, protein, and iron.

In research with the Igbo of southeastern Nigeria, 232 traditional food species were identified. Many unique foods were in danger of loss from family diets (Okeke et al. 2005) and researchers suggested that efforts should be made not only to promote the use of these nutritious food items, but to also to work to improve the methods of processing and preservation, as many of these foods were labor-intensive for women. Okeke et al. (2009) reported on the nutrient composition of traditional foods and associated contributions to energy and nutrients in eight Igbo communities. While traditional foods accounted for 90% of the energy intake, the amounts of high nutrient-density foods consumed were often low and the dietary blend of foods was often considered inadequate for good nutrition. Variations in the environment, traditional food sources, and diet among the communities were considerable, and illustrate the need for suitable intervention methods.

The case study with the food system of the Awajún of the Peruvian Amazon documented dietary quality with dietary intakes and recalls (Roche et al. 2007) as well as the corresponding nutrient values and diversity scores (Roche et al. 2008). Creed-Kanashiro et al. (2005) reported 221 potential local wildlife and agricultural foods. The main sources of energy were cassava (*Manihot esculenta*) and bananas (*Musa* sp.). Suggestions were made to increase the nutrition of the community, especially of children, through school projects and community activities promoting suri (a grub growing in palm hearts, *Rynchophorus palmarum*), macambo seeds (*Theobroma bicolor*), sachamango (local fruit, *Grias peruviana*), fish, wild meats (including coati, *Proconiadae nasua nasua* and armadillo, *Tolypeutes mataco*), snails and/or palm oils. Less than 1% of the energy of consumed foods were purchased from markets, and the dietary and anthropometric data revealed a health-promoting traditional food system that merits preservation (Roche et al. 2007).

REFLECTIONS

A wealth of information on food systems is inherent in communities of Indigenous peoples, and can be used for their benefit in concert with their priorities. An important key to success in the research is a well defined set of objectives that maintains perspective on the research by community leaders and clear and meaningful scientific process. With methods noted in this chapter, and other chapters in this volume, Indigenous leaders and scholars can contribute useful data for local and international audiences.

Food system research can be a valuable tool for community education on food security with local cultural resources, which is welcomed in school curricula and other community settings. These research data are also valuable to establish salient indicators of changing ecosystems and in tracking progress in interventions to stimulate cultural revival and health promotion programs.

There are many variations and options for the methods noted here, and the researcher is cautioned that without clear objectives it is possible to gather too much data—and have information that by necessity goes unanalyzed and unreported, therefore wasting the valuable resources and time of all involved. Researchers should work closely with their colleagues in the research team to establish the overall goals, methods, and research staff required early in the research process, and which are manageable with the resources available.

Close communication with community leaders is valuable in many ways during the research. Leaders and a project steering committee will give valuable assistance in

monitoring the perceptions and good will of the community toward the research. Local leaders can also determine the extent of the impact of external influences on the community food system, for which local vision is essential. These external influences could be sweeping harbingers of change to local food supplies, and may range from global climate change to economic development events that create jobs and income for community residents. Economic influences are also strongly felt in market food price fluctuations driven by the international economy, and new health care strategies for the community provided by regional or state governments. External influences can affect the research process and results of planned intervention programs, and must be regularly evaluated for their impact.

Indigenous peoples' food systems are dynamic. Change is constant in the availability and use of local species, and in how these resources provision nutrition and health for the community over time. With close attention and documentation to what it is that people eat, how much, and "why," communities of Indigenous peoples can maximize their health with their own local, cultural food. Further, by participation in environmental conservation and protection of food systems, lands, and environments, food resources will continue to be valuable community assets for good nutrition and health.

REFERENCES

- ARNASON T, HEBDA RJ, JOHNS T. Use of plants for food and medicine by Native Peoples of eastern Canada. *Can J Bot* 1981;59:2189–2325.
- BARTLETT JG, MADARIAGA-VIGNUDO L, O'NEIL JD, KUHNLEIN HV. Identifying Indigenous peoples for health research in a global context: a review of perspectives and challenges. *Int J Circumpol Health* 2007;66:287–307.
- BLUM L, PELTO PJ, PELTO GH, KUHNLEIN HV. Community assessment of natural food sources of vitamin A: guidelines for an ethnographic protocol. Boston (MA): INFDC; 1997.
- BRAND JC, SNOW BJ, NABHAN GP, TRUSWELL AS. Plasma glucose and insulin responses to traditional Pima Indian meals. *Am J Clin Nutr* 1990;51:416–420.
- CENTERS FOR DISEASE CONTROL AND PREVENTION. National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States, 2011. Atlanta, GA: U.S. Department of Health and Human Services.
- CIHR. Aboriginal ethics policy development. Canadian Institutes of Health Research; 2007. Available at <http://www.cihr-irsc.gc.ca/e/29339.html>. Accessed 2009 Mar 6.
- CRAWFORD S, YIP L. Using simulated pitcooks to elucidate the inedibility and culinary importance of black tree lichen (*Bryoria fremontii*). 30th Annual Conference of the Society of Ethnobiology. Verbal presentation; 2007.
- CREED-KANASHIRO H, ROCHE M, TUESTA I, KUHNLEIN HV. Aguarune food systems—potential for a food and health intervention. 18th ICN Proceedings. *Annals of Nutrition and Metabolism*. Basel: Karger; 2005. p 9–14.
- CROWELL PL, GOULD MN. Chemoprevention and therapy of cancer by d-limonene. *Critical Reviews in Oncogenesis* 1994;5:1–22.
- DAMMAN S, EIDE WB, KUHNLEIN HV. Indigenous peoples' nutrition transition in a right to food perspective. *Food Policy* 2008;33:135–155.
- DIAMOND JM. Diabetes running wild. *Nature* 1992;357:362–363.
- ETKIN NL, ROSS PJ. Food as medicine and medicine as food. *Soc Sci Med* 1982;16:1559–1573.
- FEDIUK K, HIDROGLOU N, MADÈRE R, KUHNLEIN HV. Vitamin C in Inuit traditional food and women's diets. *J Food Compos Anal* 2002;15:221–235.
- FERLAND G, SADOWSKI JA. Vitamin K₁ (phyloquinone) content of green vegetables: effects of plant maturation and geographical growth location. *J Agric Food Chem* 1992;40:1874–1877.
- HIDROGLOU N, PEACE RW, JEE P, LEGGEE D, KUHNLEIN HV. Levels of folate, pyridoxine, niacin and riboflavin in traditional foods of Canadian Arctic Indigenous peoples. *J Food Compos Anal* 2008;21:474–480.
- JENSEN J, ADARE K, SHEARER RG. Canadian Arctic contaminants assessment report. Ontario: INAC; 1997.
- JOHNS T. With bitter herbs they shall eat it: chemical ecology and the origins of human diet and medicine. Tucson: University of Arizona Press; 1990. p 6, 282, 290.
- KUHNLEIN HV. The trace element content of indigenous salts compared with commercially refined substitutes. *Ecol Food Nutr* 1980;10:113–121.
- KUHNLEIN HV. The joys and pains of sampling and analysis of traditional food of Indigenous peoples. *J Food Compos Anal* 2000;13:649–653.
- KUHNLEIN HV, CALLOWAY DH. Contemporary Hopi food intake patterns. *Ecol Food Nutr* 1977;6:159–173.
- KUHNLEIN HV, CHAN HM. Environment and contaminants in traditional food systems of northern Indigenous peoples. *Annu Rev Nutr* 2000;20:595–626.

- KUHNLEIN HV, PELTO GH, editors. Culture, environment, and food to prevent vitamin A deficiency. Boston (MA): INFDC; 1997.
- KUHNLEIN HV, RECEVEUR O. Dietary change and traditional food systems of Indigenous peoples. *Annu Rev Nutr* 1996;16:417–442.
- KUHNLEIN HV, RECEVEUR O. Local cultural animal food contributes high levels of nutrients for Arctic Canadian indigenous adults and children. *J Nutr* 2007;137:1110–1114.
- KUHNLEIN HV, TURNER NJ. Traditional plant foods of Canadian Indigenous peoples: nutrition, botany and use. Food and nutrition in history and anthropology 8. Philadelphia (PA): Gordon and Breach Science Publishers; 1991. Available at <http://www.fao.org/wairdocs/other/ai215e/ai215e00.htm>.
- KUHNLEIN HV, CALLOWAY DH, HARLAND BF. Composition of traditional Hopi foods. *J Amer Diet Assoc* 1979;75:37–41.
- KUHNLEIN HV, CHAN LHM, EGELAND G, RECEVEUR O. Canadian Arctic Indigenous peoples traditional food systems and POPs. *Senri Ethnol Stud* 2005;67:391–408.
- KUHNLEIN HV, ERASMUS B, CREED-KANASHIRO H, ENGLBERGER L, OKEKE C, TURNER N, ALLEN L, BHATTACHARJEE L. Indigenous peoples' food systems for health: finding interventions that work. *Pub Health Nutr* 2006a;9:1013–1019.
- KUHNLEIN HV, BARTHET V, FARRAN A, FALAHI E, LEGGEE D, RECEVEUR O, BERTI P. Vitamins A, D, and E in Canadian Arctic traditional food and adult diets. *J Food Compos Anal* 2006b;19:495–506.
- KUHNLEIN HV, SMITASIRI S, YESUDAS S, BHATTACHARJEE L, DAN L, AHMED S. Documenting traditional food systems of Indigenous peoples: international case studies guidelines for procedures. Montreal: Centre for Indigenous Peoples' Nutrition and Environment, McGill University, Canada; 2006c.
- KUHNLEIN HV, RECEVEUR O, SOUEIDA R, BERTI PR. Unique patterns of dietary adequacy in three cultures of Canadian Arctic indigenous peoples. *Pub Health Nutr* 2007;11:349–360.
- LILLOJA S. Impaired glucose tolerance in Pima Indians. *Diabet Med* 1996;13:S127–S132.
- McCUNE LM, JOHNS T. Symptom-specific antioxidant activity of boreal diabetes treatments. *Pharmaceut Biol* 2003;41(5):362–370.
- McCUNE LM, JOHNS T. Antioxidant activity relates to plant part, life form and growing condition in some diabetes remedies. *J Ethnopharmacol* 2007;112:461–469.
- MERCADANTE AZ, RODRIQUEZ-AMAYA DB. Carotenoid composition of a leafy vegetable in relation to some agricultural variables. *J Agric Food Chem* 1991;3:1094–1097.
- MORRISON NE, RECEVEUR O, KUHNLEIN HV, APPAVOO DM, SOUEIDA R, PIERROT P. Contemporary Sahtú Dene/Métis use of traditional and market food. *Ecol Food Nutr* 1995;34:197–210.
- NABHAN GP, BERRY JW, WEBER CW. Wild beans of the greater southwest: *Phaseolus metcalfei* and *P. ritensis*. *Econ Bot* 1980;34:68–85.
- OKEKE EC, ENEOBONG HN, UZUEGUNAM AO, OZIOKO AO, KUHNLEIN HV. Igbo local foods and their use. 18th ICN Proceedings. *Annals of Nutrition and Metabolism*. Basel: Karger; 2005. p 1–8.
- OKEKE EC, ENEOBONG HN, UXUEGBUNAM AO, OZIOKO AO, UMEH SI, KUHNLEIN HV. Nutrient composition of traditional foods and their contribution to energy and nutrient intakes of children and women in rural households in Igbo culture area. *Pakistan J Nutr* 2009;8:304–312.
- OOSTDAM JV, DONALDSON SG, FEELEY M, ARNOLD D, AYOTTE P, BONDY G, CHAN L, DEWAILY É, FURGAL CM, KUHNLEIN H, LORING E, MUCKLE G, MYLES E, RECEVEUR O, TRACY B, GILL U, KALHOK S. Human health implication of environmental contaminants in Arctic Canada: a review. *Sci Total Environ* 2005;351–352:165–246.
- RAVUSSIN E, VALENCIA ME, ESPARZA J, BENNETT PH, SCHULZ LO. Effects of a traditional lifestyle on obesity in Pima Indians. *Diabet Care* 1994;17:1067–1074.
- RECEVEUR O, KUHNLEIN HV. Benefits of traditional food in Dene/Métis communities. *Circumpol Health* 1998;96:219–221.
- ROCHE ML, CREED-KANASHIRO HM, TUESTA R, KUHNLEIN HV. Traditional food system provides dietary quality for the Awajún in the Peruvian Amazon. *Ecol Food Nutr* 2007;46:377–399.
- ROCHE ML, CREED-KANASHIRO HM, TUESTA R, KUHNLEIN HV. Traditional food diversity predicts dietary quality for the Awajún in the Peruvian Amazon. *Publ Health Nutr* 2008;11:457–465.
- ROSS W. The present day dietary habits of the Papago Indians [MSc thesis]. Tucson: Department of Home Economics, University of Arizona; 1944.
- SCHMID MA, EGELAND GM, SALOMEYESUDAS B, SATHEESH PV, KUHNLEIN HV. Traditional food consumption and nutritional status of Dalit mothers in rural Andhra Pradesh, South India. *Eur J Clin Nutr* 2006;60:1277–1283.
- SCHMID MA, SALOMEYESUDAS B, SATHEESH P, HANLEY J, KUHNLEIN HV. Intervention with traditional food as a major source of energy, protein, iron, vitamin and vitamin A for rural Dalit mothers and young children in Andhra Pradesh, South India. *Asia Pacif J Clin Nutr* 2007;16:84–93.
- SIMS J, KUHNLEIN HV. Indigenous peoples and participatory health research planning and management. Preparing research agreements. WHO; 2008. Available at http://www.who.int/ethics/indigenous_peoples/en/print.html. Accessed 2009 Mar 6.
- SMITH CJ, MANAHAN EM, PABLO SG. Food habit and cultural changes among the Pima Indians. In: JOE JR, YOUNG RS, editors. Diabetes as a disease of civilization: the impact of culture change on Indigenous peoples. New York: Mouton de Gruyter; 1994.
- STINTZING FC, CARLE R. Cactus stems (*Opuntia* spp.): a review on their chemistry, technology, and uses. *Mol Nutr Food Res* 2005;49:175–194.
- TEUFEL NI. Nutrient characteristics of southwest native America per-contact diets. *J Nutr Environ Med* 1996;6:273–284.

- TURNER NJ, KUHNLEIN HV. Camas (*Camassia* spp.) and rice-root (*Fritillaria* spp.): two liliaceous "root" foods of the Northwest Coast Indians. *Ecol Food Nutr* 1983;13: 199–219.
- TURNER NJ, THOMAS J, CARLSON BF, OGILVIE RT. Ethnobotany of the Nitinagt Indians of Vancouver Island. Occasional papers series 24. Victoria: British Columbia Provincial Museum. 1983.
- UNLU NZ, BOHN T, CLINTON SK, SCHWARTZ SJ. Carotenoid absorption from salad and salsa by humans is enhanced by the addition of avocado or avocado oil. *J Nutr* 2005;135:431–436.
- UNPFII. Data collection and disaggregated data. United Nations Permanent Forum on Indigenous Issues; 2007. Available at <http://www.un.org/esa/socdev/unpfii/en/data.html>. Accessed 2008 Jan 3.
- WILLIAMS DE, KNOWLER WC, SMITH CJ, HANSON RL, ROUMAIN J, SAREMI A, KRISKA AM, BENNETT PH, NELSON RG. The effect of Indian or Anglo dietary preference on the incidence of diabetes in Pima Indians. *Diab Care* 2001; 24:811–816.
- YOUNG TK. The health of Native Americans: towards a bio-cultural epidemiology. New York: Oxford University Press; 1994. p 139–143, 145–168.

Chapter 16

Ethnoecology and Landscapes

LESLIE MAIN JOHNSON

Athabasca University, Athabasca, AB

IAIN DAVIDSON-HUNT

University of Manitoba, Winnipeg, MB

INTRODUCTION	268
LANDSCAPES AND ETHNOECOLOGY	268
PERSPECTIVE, VIEW, AND REPRESENTATION	268
LANDSCAPE STRUCTURES, PATTERNS, AND THE IMPORTANCE OF SCALE	269
LANDSCAPE MANAGEMENT	269
LANDSCAPE ETHNOECOLOGY IN ETHNOBIOLOGY	269
LAYING OUT APPROACHES TO RESEARCH IN LANDSCAPE ETHNOECOLOGY	270
CONCEPTS, TERMS, AND APPROACHES TO LANDSCAPE ETHNOECOLOGY	270
PARTS OF THE LANDSCAPE	272
KINDS AND KINDS: ONE CLASSIFICATION OR MANY?	272
FOCUS ON ANIMALS, BIRDS, AND FISH	273
SUBSTRATES	273
LANDSCAPE PROCESSES	273
WIND AND WEATHER	273
OF WATERWAYS, SEASCAPES, AND ICE-SCAPES	274
THE SACRED IN LANDSCAPE STUDIES	274
UTILITY AND LANDSCAPE KNOWLEDGE	275
NAVIGATING LANDSCAPES	275
ORIENTATION	275
THE TRAVELER'S PATH AND PLACES OF HAZARD	277
TOPONYMY	278
INTEGRATION: KNOWLEDGE OF THE LAND IN THE ROUND	278
READING ETHNOECOLOGICAL LANDSCAPES: METHODS	278
DICTIONARIES, WORDLISTS, AND RECORDED NARRATIVES	279

INTERVIEW METHODS	279
VISUAL METHODS IN INTERVIEWS: ELICITATION AND DOCUMENTATION	279
FIELD TRIPS AND ON-THE-LAND PARTICIPATION	280
PLOT STUDIES, REMOTE SENSING, AND SPECIALIZED APPROACHES TO VEGETATION AND RESOURCES	280
REFERENCES	281

INTRODUCTION

Ethnoecology has a complex provenance ranging from a consideration of cultural understandings of the relationships among organisms (Ford 1994) to an applied focus on the utility of such understandings to community development and community-based resource management (Beaucage et al. 1997; Clément 1998; Posey 1984). Some authors include cognitive and symbolic knowledge together with practices associated with organisms and their interrelationships (Toledo 1992, 2002).

Only recently have we tried to understand how people think about spatial (and temporal) distributions of organisms and conceive of the elements of the land itself (Johnson and Hunn 2010). Early work on these questions introduced the concept of landscape into ethnoecology (Martin 1993; Hunn with Selam 1990). The similar interest that has surfaced in the literature on traditional ecological knowledge (Berkes et al. 1998) is often rooted in the concept of ecosystems. Our focus in this chapter is to introduce the concept of landscape in ethnoecology. We provide methodological approaches for investigation of the processes, forms and patterns of life from emic and etic perspectives.

LANDSCAPES AND ETHNOECOLOGY

Seemingly a straightforward term, *landscape* has been used in a number of contrasting ways in ecological, geographic, anthropological, and archaeological literatures. Three broad approaches to landscape have ethnoecological significance: landscape as perspective or view and, related to this: landscape as representation; landscape patterns, structures, and the significance of scale; and landscape as foundation of land management.

Perspective, View, and Representation

In the humanistic literature, “landscape” has been used in examinations of the relationship between perspective and view, or what some scholars have termed *viewscape* or *prospect* (Gow 1995; Tuan 1974). One contribution of this literature, which has focused on landscape painting and photography, is that the representation (a painting or a photograph) of a landscape relates to the perspective of the viewer. *Perspective* is key, placing attention on the role of the person in creating the representation from a vantage point. Humanists emphasize that landscape is a relational concept, bringing together the viewer and the view. A landscape is a spatial representation, which emerges out of the interrelationship among the social, cultural, and biophysical, and is thus a useful concept in social-ecological or biocultural analysis (Berkes et al. 2003; Maffi 2001; Stepp et al. 2002).

The aesthetics of landscape representation reflect cultural conceptions of “the natural” and are situated in cultural, location, and historical contexts. As Humphrey (2001: 55,

following Hirsch and O'Hanlon 1995: 1) writes, "I use 'landscape' to refer to the meanings imputed by local people to their cultural and physical surroundings." Landscapes are thus sites of contested terrain and identity formation; representation and meaning are dynamic and processual.

The English concept of landscape is rooted in the Germanic concept of *landschaft* (Olwig 1996). As noted by Olwig (1996: 633, original emphasis), "The link between customary law, the institutions embodying that law, and the people enfranchised to participate in the making and administration of law is of fundamental importance to the root meaning of *Land* in *Landschaft*." The suffix in landscape, *-schaft*, is derived from a verb that means "to create" or "to shape." Taken together, landscape expresses a unity that emerges out of the interaction between the physical morphology of a bounded territory and the values, customs, and practices of a people. Landscapes were the nexus of customary law and cultural identities (Olwig 1996: 633). The result in northern Europe was that a land could be incorporated into a larger land and still maintain its character if it retained its law and customs, or what was referred to as its landscape law (Sauer 1925).

Landscape Structures, Patterns, and the Importance of Scale

The consideration of patterns of spatial and temporal organization that exist at spatial scales is a second fundamental approach to landscape ethnoecology. A landscape encompasses a range of different features such as agricultural fields, hedgerows, groves, shorelines, mountains or hills, habitations, fences, and living things in the area. Fixed structures may be referred to as "landscape elements" by geographers.

Ecology has introduced many concepts to the understanding of the relationships of organisms. These have ranged from more qualitative approaches to understanding communities of organisms, habitats, and ecosystems and the flows of energy and material that sustain them, to more quantitative approaches (e.g., Forman 1982). *Habitat* foregrounds the association of specific species of plants or animals with a constellation of ecological conditions, and in some cases has been extended to a series of recognized ecological associations called habitat-types (cf. Pfister and Arno 1980). While it is tempting to attribute a specified scale to a "landscape," it is useful to remember that the size of the landscape is dependent upon the viewer and the vantage point of the viewer. Landscape, at best, is a sliding scale: for example, the "landscape" of a vole with a restricted home range may be orders of magnitude smaller than the relevant "landscape" of a male grizzly bear (cf. McGarigle, no date).

Landscape Management

There is also a practical, applied reason to consider landscapes. "Landscape" has become a dominant paradigm in the management of the environment and natural resources. By studying the ways different societies understand or construct landscape, ethnoecologists can question the ways dominant societies pattern space for their management.

Landscape Ethnoecology in Ethnobiology

In ethnobiology, a focus on landscape must be *ethnoecological*, comprising both domains of meaning and knowledge of the biophysical landscape, its creatures and plants, and its

landforms and waterways (see Berkes 2008; Sillitoe 1996; Toledo 1992, 2002). For an ethnobiologically pertinent focus on landscape, the appropriate scale is typically of the order of a medium-sized drainage basin, a mountain range or island and surrounding waters . . . the area of lands and waters comprising the homeland of a local group. In this sense “landscape” lies between a local habitat or specific environmental type, and a large regional or global expanse. The focus is on the knowledge of specific groups, and is grounded in a consideration of landforms, vegetation, animal habitats, and waterways: the biophysical environment.

Dividing lines between lands and waters, and between biological and climatological elements, are not hard and fast, so understandings of landscape processes include winds, weather, and seasons.

Laying out Approaches to Research in Landscape Ethnoecology

The Mexican ethnoecologist Victor Toledo was one of the first scholars to formulate an approach to ethnoecology which integrated a functional and cosmological appreciation of landscape with vegetation classification and management (Toledo 1992, 2002). He focused especially on human appropriation of nature through subsistence production, and conceived of ethnoecology as involving what people do (practice, embodied knowledge), what they know (cognized knowledge), and their overall worldview or cosmovision, including sacred aspects of understanding the world and the human place in it. He writes:

Ethnoecology can thus be defined as an interdisciplinary approach that explores how nature is viewed by human groups through a screen of beliefs and knowledge, and how humans use their images to acquire and manage natural resources. Thus, by focusing on the *kosmos* (the belief system or cosmovision), the *corpus* (the whole repertory of knowledge or cognitive systems) and the *praxis* (the set of practices), ethnoecology offers an integrative approach to the study of the process of human appropriation of nature. . . .

—Toledo 2002: 514

A number of questions emerging from our review of landscapes and ethnoecology serve as starting points for a research program on landscape ethnoecology. One of the first tasks is to examine whether different societies do perceive, classify, name, and identify associations of organisms and landscape elements at different spatial scales: habitats, “ecotopes” (Tansley 1939), and patches, and also ideas of territory, identity, and ways of life. This will involve contested perceptions or notions of relations to the land. There may be overlapping layers of landscape with differing boundaries, flow, or shifting areas with indefinite boundaries. Finally, landscapes are sites of memory, which allow people to navigate space and time on a daily basis, and sites of action in which a landscape is fashioned and the survival of individuals and societies secured (Bender 1993, 2002; Collignon 2006; Ingold 2000; Tilley 1994).

Concepts, Terms, and Approaches to Landscape Ethnoecology

Landscapes were theorized in geography by Carl O. Sauer (1925) and by Yi-Fu Tuan (1974) as humanized environments comprising both biophysical features, and human features and perceptions. More recent theorists like Olwig (1996) have sought to bring back a “substantive” view of landscape, which includes custom, law, and social institutions, as well as space. None of these perspectives is specifically ethnobiological or ethnoecological, though these

BOX 16.1 *Concepts, Terms, and Approaches to Landscape Ethnoecology*

Some researchers in landscape ethnoecology have used *habitat* or *habitat-type* as a focus of their analysis, such as Shepard et al.'s work with the Matsigenka of eastern Peru, or Michael Gilmore's study of the Maijuna, also in Amazonian Peru (Gilmore 2005, 2010; Shepard et al. 2001).

Other researchers have focused their analysis around the concept of *landscape element*, a term more derived from geography than ecology. Landscape elements can include any component of the landscape. Julia Krohmer's (2004, 2010) detailed analysis of Fulani landscape knowledge is organized around landscape elements.

Veronica Strang (1997) has used the concept of *cultural landscape* to examine grazier and Aboriginal understandings of landscape in northern Queensland, Australia. Her work touches on more specific biological content of different areas recognized on the land, and illuminates the particular and localized perspectives of the Aboriginal residents of the Murray River area. Iain Davidson-Hunt and Fikret Berkes (2003, 2010) have also described Anishinaabe landscape understanding in terms of a cultural landscape. In their presentation, the cultural landscape comprises numerous Anishinaabe terms for cultural ecotopes, which include both

biophysical and hydrographic features (including human uses), and cultural and spiritual sites. They also elucidate understandings of succession and seasonal timing tied to the lunar cycle through the year, as well as how learning takes place, and how resource sites are located. Another significant anthropological approach to landscape, with variable ethnobiological content, is through the study of *toponyms* or place names (Basso 1996; Hunn 1996; Kari and Fall 1987; Thornton 1997, 2008). These encode a great deal in terms of the content of place names, indications of ecological and cosmological connections, and a deep sense of the ethnoecological relationship to land. The approach to landscape through named places and analysis of their names can be very rich; it is also of necessity very particularized, dependent on linguistic conventions; it may be proprietary, and the degree of ecological information is likely to vary according to cultural factors (Rodman 2003). Athapaskan languages in North America, with their polysynthetic structure, verbal basis, and rich set of locational indicators, can indicate an engaged and located approach to landscape as locus of story and moral values, as Keith Basso (1990a,b) has eloquently explained.

perspectives are supportive of ethnobiological research. Similarly, the rich cultural landscape theorizing of archaeologists is supportive of an ethnobiological perspective on landscape, but does not actually undertake ethnobiological, or paleoethnobiological, analysis. Key works include Tilley's *Phenomenology of Landscape* (1994), and two volumes edited by Barbara Bender (1993; Bender and Winer 2001). Some scholars working on landscape perception and management describe cultural landscapes in more contemporary settings, an approach particularly taken by those involved with heritage conservation (see Box 16.1).

Metaphor in landscape can also be richly indicative of larger ecological relations of peoples with landscape, as Taller de Tradiccion Oral del Cepec and Pierre Beaucage et al. (1996) indicated for Sierra Nahua, describing a large polarity between the "good" mountain, and the "evil" river. Joseph Bastien (1978) demonstrated for the Ayllu of Kaatan in the Bolivian Andes that ecological and social relations between different levels of the mountain (Mount Kaata) are conceptualized and mediated by an explicit metaphoric understanding of the mountain as a body, with appropriate anatomical parts which function in the local ritual cycle and are implicated in spiritual understandings of cosmology and life/death and rebirth. At a less highly developed level, people in English may speak of parts of rivers in terms of human anatomy (the head of a river, the mouth of a river) and Wola in New Guinea may interpret river elements in terms of an analogy to plant anatomy, with "forks," "base," and "sprout" used both for parts of plants and parts of rivers (Sillitoe 1996: 111). In

places with significant altitudinal variation, especially in tropical high mountains, the dimension of hot–cold lands has both agronomic and symbolic or spiritual significance (Bandeira et al. 2002; Bastien 1978; Maffi 1999; Martin 1993).

More recently, Johnson and Hunn (2010) and Hunn and Meilleur (2009) have approached landscape from the perspective of landscape ethnoecology. Mark and co-authors have described a subdivision of geography which they call ethnophysiography (2003, 2010). German scholars such as Krohmer (2004, 2010) have called their approach geocology. These latter approaches are more explicitly ethnobiological.

Parts of the Landscape

Each language has basic terms for kinds of places on the landscape. English terms include: for local landforms: sand dune, hill, cliff, ridge; waterbodies: pond, oxbow, waterfall, delta; vegetation: pine barrens, willow thicket, prairie; and for glacier: pack ice, snowfield, or salt pan (See Box 16.2). To some degree the glosses for locally named features of similar general landscapes seem familiar; features named in the French Alps may bear some resemblance to the types of features named in the glaciated mountains of coastal British Columbia, at least when we deal with the common features of the physical and hydrographic realms. The names for types of vegetation may in fact vary significantly, both because of different local climate and flora, and because of quite different traditional ways of making a living between the two regions. In Les Allues, Savoie (Meilleur 2010), for example, the rural folk have been small-holder farmers, with herds and orchards, while in the Coast Mountains of British Columbia, a traditional seasonal round focused on hunting, salmon fishing, fur trapping, and berry picking directs attention to different features of the environment for the Gitksan and Witsuwit'en (Johnson 2000, 2010b; Johnson and Hargus 2007).

Mark et al. (2010) have been interested in examining the landscape classifications of people living in arid lands in Australia (Yindjibarndi) and in the southwestern United States (Navajo), to look at how linguistically unrelated groups, with somewhat contrasting ways of life, may classify similar landscapes.

Kinds and Kinds: One Classification or Many?

Aside from the question of what kinds of elements of landscapes are recognized and are significant for local groups, there is another question: are all “kinds of place” part of a unified system? Are there overlapping systems which intersect in some manner to produce grids where any location can be designated by, say, vegetation *and* physiography?

BOX 16.2 *Naming Vegetation Types*

Vegetation is often named after a conspicuous or dominant plant. A feature of Mixe naming of vegetation types is to call them a “place of _____”—as in *tsoots kam* meaning “grass place,” *xjkam* “oak place” (e.g., an oak forest), *tsa’am ju’u kam* “blackberry place” (a blackberry patch), or *tsimkam* “fern place” (a fern meadow). Cultivated fields or orchards can also be named using the same construction, giving *mkkam* “place of corn” (cornfield)

or *cafekam* “place of coffee” (coffee grove). Many languages exhibit this pattern; for instance, the Kaska Dena, an Athapaskan speaking group from northern British Columbia and the southern Yukon in Canada, refer to a pine forest as *gǫdze tah* “pine on it.” We say “cottonwood stand” in English, meaning that cottonwood is present at the site; see also Latin *-etum* as in *arboretum*, “place of trees.”

Focus on Animals, Birds, and Fish

Although they are mobile, mammals, birds, and fish can be important focal points in defining and orienting ecotopes. Game trails, nesting areas, and mineral licks may be important local ecotopes. Escape habitat for ungulates may be a factor that differentiates between different types of alpine environment, for example grassy alpine versus “rock” mountains with steep cliffs (Johnson 2010a). For Kaska in the southern Yukon, “fish lake” is an important kind of lake, and elders familiar with different areas will tell you what fish are found in which lakes. Similarly, environments such as “salmon rests” are known to peoples who live on rivers where salmon run (cf. Johnson 2000). For Inuit and Iñupiat, detailed knowledge of seal and walrus behavior and sites where they can be hunted inspires a vocabulary to distinguish different sites, seasonal factors, and weather conditions (Aporta 2002; Nelson 1969).

Substrates

The degree to which soils or substrates are attended to and named appears to vary among cultures, with cultivators such as the Maya (Anderson 2010; Atran 1993; Bandeira et al. 2001) or Wola of New Guinea (Sillitoe 1996) elaborating local classifications of soil which have significance for cultivation. American farmers also describe soils in terms of factors such as clay content and acidity: is the soil “light” or “heavy,” “sweet” or “sour”?

Landscape Processes

In heavily vegetated environments, especially those with a high degree of plant diversity, landscape studies may focus particularly on examining the understanding that local peoples have of the variation of vegetation by composition and stature. One important dimension is *seral stage*: the more or less regular series of vegetation types which reoccupy a site which has been subjected to a disturbance, such as a forest fire, landslide or, more typically, land clearance. Gary Martin’s (1993) research with the Chinantec and Mixe in the mountains of Oaxaca, Mexico, elucidated different vegetation formations, including those that develop through time after clearing a milpa. He also documents local understanding of the altitudinal zonation of vegetation, and of forest regrowth.

Some terms which indicate landscape dynamics directly are terms such as *witlat* “slide area,” the Witsuwit’en term for an area which has experienced land slippage, or *lax en suuks*, the Gitksan term for a place which has downed logs on it, for example, an avalanche or landslide track through forested terrain. (If the logs are being transported on floodwaters, they are still referred to as *suuks*.) Another frequent term indicating the dynamic landscape is “burn” (for the English example), or *lax an mihlw* (“place of charring”—Gitksanimax). Perhaps less directly, terms like “oxbow” or “slough” (Kaska: *tū íli*) may indicate awareness of changing channel positions on active rivers. A sense of seasonal dynamic is expressed through terms such as “frost pocket,” indicating a site prone to early or late frost, as a consequence of cold air drainage, or “flood plain,” indicating sites subject to periodic or episodic inundation.

Wind and Weather

Wind and weather are not fixed; they are part of the dynamic perception of the land. In mountainous regions, upslope and downslope winds are important in landscape process and are often named. In winter in the coast mountains of British Columbia, coastal winds and outflow winds bring very different conditions. The Haisla considered strong outflow

winds life-threatening, as they could freeze the inlet surface waters solid, and blow small boats out to sea. Working among Gwich'in in the Mackenzie Delta, Johnson quickly learned the names for the prevailing winds, and something of their patterning (unpublished field notes). Aporta also gives details of the significance of named winds in terms of ice dynamics and hunter safety in the Iglulik region (Aporta 2002, 2010).

Of Waterways, Seascapes, and Ice-Scapes

Although the previous discussion has largely dealt with *lands* and, to a lesser degree, watercourses, the domain includes waterways, seascapes, and ice-scapes. It is partly a factor of our deeply embedded English language landscape ethnoecology that we cannot easily indicate home-“lands” which may include substantial areas of water. Indeed, this has had ramifications in international law, where maritime peoples such as the Torres Straits Islanders (Mulrennan and Scott 2010), the Makah of Washington State, and the Inuit in Nunavut have had difficulties defining and maintaining control over their traditional home regions. Aporta (2002, 2010) describes an elaborate vocabulary for the features of moving and stationary ice, and details named places and traditional village sites on pack ice around Iglulik, Nunavut, Canada. Beatrice Collignon (2006) similarly describes how, during the former seasonal round of the Inuinait of the Central Canadian Arctic, people spent the winter season on the pack ice and the summer on the land. Peoples of the Northwest Coast were and are highly maritime people, frequenting coastal waters and living largely at the productive interface of land (or river) and sea. Named places indicate environmental conditions and resources on both land and sea (Thornton 1997, 2008). Johannes (1981) has documented a rich knowledge of waters and water features around Pacific atolls. Access to marine resource sites may be owned in traditional Polynesian systems (Alkire 1991).

The Sacred in Landscape Studies

One category of kinds of places on the landscape which is highly culturally specific is the category of sacred places or areas. The defining characteristics of these sites and areas are not derived in obvious ways from biophysical or ecological characteristics, but they have great significance for local peoples, and often have important ecological entailments. It has been argued that these types of sites should be considered “special purpose classes” rather than “general purpose classes” because their defining features are not primarily biophysical (see discussion in Johnson and Hunn 2010: 17, 283). While it is true that the characteristics of sites with spiritual power are not primarily biophysical, there are entailments to sacred sites and relationships in the behavior of local peoples, and sacred sites such as groves may create islands of high biodiversity in otherwise heavily managed landscapes (Ellen 2010; Kunstadter 1994; Sillitoe 1996).

In *Topophilia*, Yi-Fu Tuan (1974) gives prominence to cosmology and spiritual perspectives as organizing perceptions of landscape. Davidson-Hunt and Berkes (2003, 2010) found that their Anishinaabe collaborators felt that a representation of landscape which omitted human sites and sacred sites was incomplete. Johnson found that both specific named sites and types of sites which had spiritual power were described in the various places she has worked. Sacred sites are implicated in the instantiation of the moral on the landscape, and serve as a reminder of proper behavior (e.g., Shiltee Rock on the lower Peel River; Johnson 2010b; Gwich'in Social and Cultural Institute, no date). There has also been some research on the characterization of sacred sites: are there characteristics that predispose a particular site to being considered a sacred site? A provocative analysis of sacred rock art

sites along the Central Arkansas River suggests the association of local sacred sites with unusual rock forms, and connections with cosmological symbolism and local social structure (Sabo 2008).

Utility and Landscape Knowledge

Both *what* is named, and the correspondence or points of discontinuity between different systems of landscape terminology are significant. There is also much tacit or embodied knowledge of landscape; features may not be explicitly named, but the entailments or affordances of particular configurations of species, landforms, and so on are well understood by local people (Ellen 2010; Johnson 2000, 2010a,b).

Eugene Hunn has suggested that the kinds of ecotopes recognized by local peoples tend to be *adaptive*, that is, the types of sites it is needful to know and recognize to be able to make a living successfully in a given environment (Johnson and Hunn 2010: 3, 24, 179). By this reasoning, one might expect that people who live in arid lands may have a finely detailed terminology for and recognition of water bodies, to locate water for people or their livestock (e.g., Krohmer's Fulani study 2004, 2010). By the same token, fishers or those who travel on rivers would be expected to have a well elaborated classification of and ability to recognize features of rivers such as "eddy," "whirlpool," sand bar, canyon, current, channel, backwater, and so on. Such river terms may be highly specific, and may lack direct translations into English. The Gitksan terms for places on rivers shown in Figure 16.1 include *t'aamiks* "slow side channel"; *ts'oohlxs* "back channel, slough, without current," significant for fishing; and *ts'iliks* and *'nii lok*, two terms which indicate hazardous rocks below the water surface, important for safe canoe travel.

Utility in various ways is encoded in ethnoecological awareness of landscape. One whole class of terms relates to anthropogenic ecotopes, such as road, trail, village, camp, field, orchard, garden, and quarry. In urbanized or densely settled environments, these place-kinds of human creation may predominate. But even among groups who do not evidently transform much of their landscapes, categories such as trails may be important. For the Kaska, there are generic trails, *atane* (focally human travel trails), and also animal trails, differentiated by species such as *kedātane* "moose trail." Trails provide *linkages* among different sites in the local landscape or homeland and may also have particular characteristics, such as public access in places which have owned territories (e.g., the Witsuwit'en of northwest British Columbia). As Western ecologists know, trails are lines of disturbance as well, and may therefore have distinctive flora at their margins. Among Athapaskan speakers in northwestern Canada, places where a hunter can gain a good prospect of terrain where game may be encountered are recognized, taught, and named—"lookout" in English, *coēnkit* in Witsuwit'en (also indicating a place from which one looks). Another widely disseminated category of place that relates to animal ecology, and to hunting, is the salt lick, or mineral lick.

Navigating Landscapes

Orientation

Part of the way people perceive landscape is through systems of orientation. Western readers are familiar with the directions used on standard maps, and those who are involved in orienteering or boat navigation will also be familiar with designations like NNE or SW. This familiar system is a set of *cardinal directions*, directions based on geometry, and

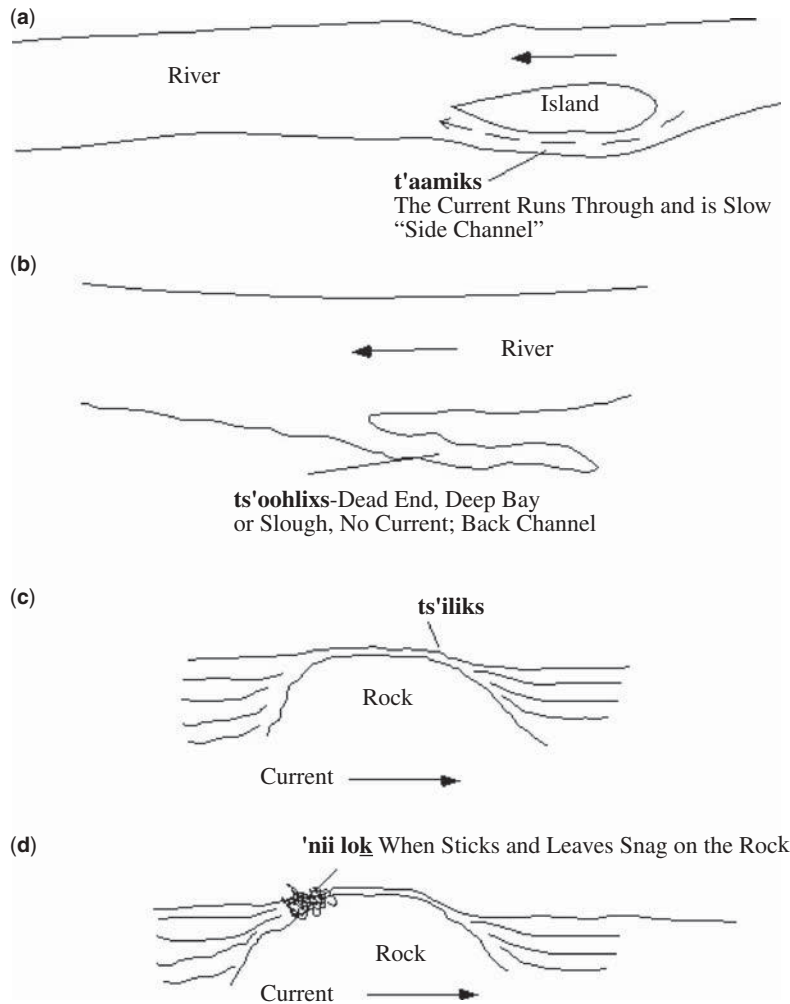


Figure 16.1 Diagrams of some Gitksan river terms as explained by Art Mathews; (a) and (b) are map views; (c) and (d) are side views.

usually a quadrant system, and oriented to something other than local geographic features. Caroline Islands navigators had an elaborate star compass system which could designate 32 directions, and enabled travel between distant Polynesian atolls by outrigger canoe (Goodenough 1996; see also Gladwin 1970). Other systems of orientation may instead be dependent on specific landscape features, such as upslope/downslope, and upriver/down-river (Fig. 16.2). The Gitksan and Witsuwit'en peoples of British Columbia use such a system, as do Austronesian speakers of interior Borneo. On the Hawai'ian Islands, the directions *mauka* (toward the mountain) and *makai* (toward the sea) are important in orientation. The other aspect of Oahu geography Johnson recalls from her youth was the significance of windward (the side of the island facing the prevailing trade winds) and leeward (the rain-shadow side in the lee of the volcanic ridge that runs the length of the island). A more subtle use of wind in orientation is found among the Inuit, where the wind system comprises four cardinal directions based on prevailing wind directions; this system is offset from the Western N-E-S-W, but serves for orientation in the Iglulik region (Aporta 2002).

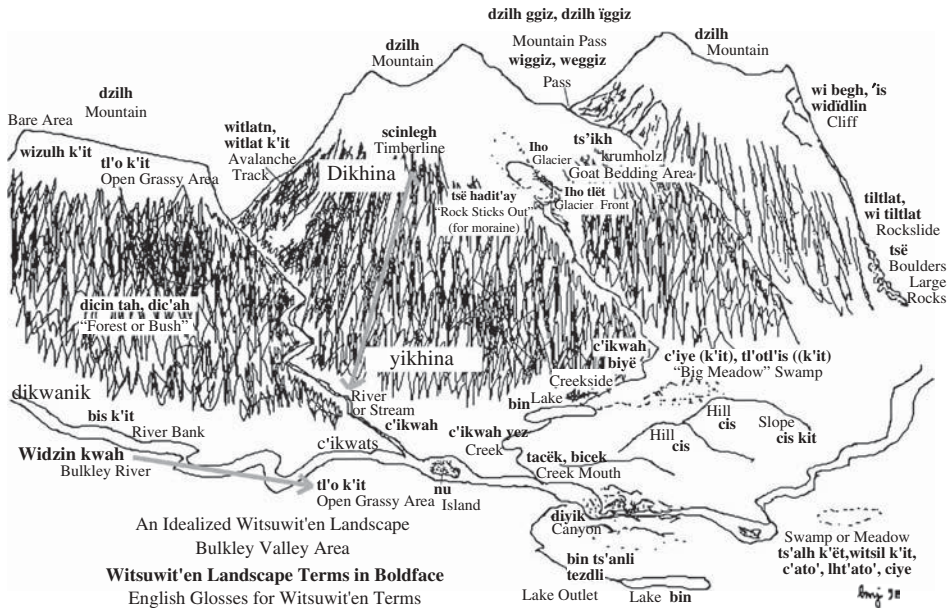


Figure 16.2 Dene orientation: a Witsuwit'en example (modified from *Trail of Story, Traveller's Path*, Athabasca University Press; 2010).

The Traveler's Path and Places of Hazard

Landscape knowledge can be organized as a series of paths or trails, spotted with significant resource areas, camp sites, and other named features. The genre of toponymic song is a particularly strong example of this local way of organizing landscape knowledge, and has been described for Paiute in the arid west (Fowler 2010), Sahaptin of the Columbia Basin (Hunn 1996), Seri (Comcáac) of the Gulf of California (Monti 2002, 2003), and Inuinnait of the Canadian Arctic (Collignon 2006). Navigation, location of resource sites, and especially locations of places of travel hazard are evident functions of these songs. Places of travel hazard are prominent in narratives about moving on the land as well. Legat et al. (1995: 15) comment that toponyms on waterways and topographic features in the taiga and tundra in the Tłı̄chǫ area of Canada's Northwest Territories appear to indicate features significant for travel, while place names for land areas are more likely to be focused on available biological resources. Their writing in patterns associated with place names suggests that names that contain topographic and water flow terms have the primary purpose of describing safe understandable travel routes, whereas the primary purpose of the place names containing biological terms seem to indicate locations with various resources or biodiversity. David Pentland's (1975) pioneering study in northern Algonquian ethnocartography shows rivers as travel routes, highlighting both fish resources and travel hazards. The intent and purpose of the maps is clearly different from maps in the European tradition, as large geographic features which are not on the routes of interest are omitted, but detailed description of travel hazards and significant fishing sites along the rivers are provided, and alternative routes which avoid impassible sections are included. A more recent examination of route orientations and mental maps is found in Istomin and Dwyer (2009). One of the most interesting aspects of their study shows striking contrasts between two adjacent reindeer herding groups in Russia: the Komi orient primarily along fixed travel routes, while the Nenets saw their land as set of specified areas, within which a nested set of specific environments and

named places was mapped. Istomin and Dwyer also refer to gender differences in orientation, which may reflect different gender roles in society, showing that a great deal of empirical research on wayfinding and how people understand landscapes remains to be done.

Toponymy

In much of everyday experience, people think, speak, and orient action toward specific *named* places. Maori biologist Mere Roberts responded to a question about Maori landscape terms some years ago with the comment that she thought that specific named places were the way that her people oriented toward land. Documentation and study of named sites can be revealing of specific knowledge of resource economies, and of regional history and cosmology (Fowler 2010; Hunn 1996). Named places can be very significant in long distance travel and orientation as landmarks, as James Kari has documented for Alaskan Athapaskan speakers (Kari 1989; Kari and Fall 1987). Place naming can be a genre of oral literature as well, demonstrating deep connections with land and a kind of mental travel (Fowler 2010; Hunn 1996; Thornton 1997, 2008), and for groups like the Gitksan, naming the places and knowing the stories associated with these sites demonstrates familiarity with the boundaries of owned group territories (Johnson 2010b). Named sites can also instantiate identity, and reclaiming space and reaffirming connection to territory may be accomplished through the restoration of local or Indigenous names, either on maps (e.g., Collignon 2006; Müller-Wille 1993), or by signage literally on the ground (Schreyer 2006).

Integration: Knowledge of the Land in the Round

It is a cliché to say that traditional knowledge is holistic. The landscape and those who dwell there are in some sense mutually constituting (Ingold 1993: 162, citing Inglis 1977: 489). Many Indigenous societies focus on relationships and connections among entities and inhabitants of landscapes, and with the humans who make the region their home. Agency is distributed. People conceive of plants, animals, and even landforms and waterways as having awareness and the ability to act, facilitating human welfare when appropriate behavior is followed, and challenging human will when it is not. David Anderson (2000) has termed this “sentient ecology.” Richard Nelson (1983) described the boreal forest homeland of the Koyukon as “the watchful world.”

Reading Ethnoecological Landscapes: Methods

It is difficult to collect a “voucher” specimen of a river, pond, or talus slope, though photographs can serve. Interviews and dictionary work, if not checked against actual locations, can create inaccurate correspondences or understandings of local knowledge. Initial interviews or focus groups can also be useful, though translation of terms across language boundaries without double-checking their referents can create misunderstandings. Field trips or participant observation on the land are deeper ways to discover and document culturally significant ecotopes and toponyms. A special kind of field trip is the plot study, which combines Western scientific vegetation sampling methods with interview work. Visual documentation and visual elicitation are important in landscape research; mapping, with or without recent technological tools like GPS, satellite photos, and GIS is a fundamental tool. Collaborative methodologies, where researchers work closely with communities, may use most of these methods, and are particularly well suited to a rich presentation of local understanding of landscape.

Dictionaries, Wordlists, and Recorded Narratives

Dictionaries and wordlists can be quite useful initial points in landscape research in a local area (Mark et al. 2010). Examining dictionaries and vocabularies can give a sense of the range of features that may be recognized, and their general nature, as well as indications of grammatical construction of place and landscape terms. Such materials are natural beginning places for follow-up research through interviews, focus groups, and field trips. Significant is the lack of cultural context inherent in dictionaries and wordlists. Such materials may also be lacking or very rudimentary for the particular area and group one is working with.

A similar approach is the analysis of lists of toponyms for “place kind generics,” a method used Kari and Fall (1987) and by Hunn (2008). Place names are often composed of a specific name coupled with a place-kind term, such as “Sherwood Forest,” or “San Francisco Bay.”

One can go over a series of recorded narratives, either in the original language or in translation, to list the references to place names and settings for actions or activities to make a preliminary listing of kinds of places named, types of place names, and kinds of place recognized or described. The cultural content of such sources is high, though the original context of the narrative may not be apparent from the recorded materials.

Interview Methods

An interview can be directed through use of maps or visual materials such as photographs, or by reference to previous work. Recording of interview materials may be by written notes, or by audio- and or video-recording. Unless the researcher is very conversant with the local language and expert at accurate transcription of terms, it is probably best to use some kind of recording device to allow for accurate transcription by the researcher at a later date, or by a specialized linguist. It may be difficult to elicit generic landscape terms through such natural questions as “Where do you find cow parsnip?” Working in Savoie, Brien Meilleur found that if he asked where would *you* find . . . , his informants gave specific sites. He had to develop a specific question frame to elicit the terms for Savoyard generic ecotopes, asking instead where would *one* find (plant name) (Meilleur 2010).

Interviews can be focused around animal or plant habitats. This will likely yield ecotopes of high biological relevance. Terms for other landscape features, such as landforms and waterways, may be more readily elicited through travel narratives.

An outgrowth of interview techniques is the group interview, or focus group, for example, a topical community meeting of elders or knowledgeable people. The dynamics of such group settings may facilitate memory, add to consultant comfort, and allow cross-checking of data, but group effects can also silence some voices, perhaps giving more play to dominant subgroups within the community, or to one gender or age group.

Visual Methods in Interviews: Elicitation and Documentation

If the researcher is familiar with the local region and has some sense of important or prominent local places or place-kinds, he or she can use photographic materials or diagrammatic drawings in eliciting landscape terms, discussions of relationships of different ecotopes or landscape elements, or narratives about specific places. Johnson has used such methods when working with Gitksan and Witsuwit'en elders, building on a number of years of

prior ethnobotanical research and travel in the region. An initial attempt to create a set of appropriate photographs for a similar approach in the Yukon was less successful, both because of her lack of deep familiarity with the region, and because her consultants were unused to looking at photographs of landforms and generic vegetation types. A special form of visual methodology involves mapping; one can work from existing maps, such as topographic or forest district maps, if the consultants are familiar with such maps; otherwise the consultant or interviewer may record spatial relationships of landscape features or travel routes through sketch maps. Vitebsky (2005: 319) includes an Eveny map of reindeer range which is quite remarkable. A detailed methodology involving “map biographies” has been developed for Land Use and Occupancy Studies in Canada (Freeman 1976; Tobias 2000). Such maps may contain significant information about spatial distribution of subsistence activities, seasonal camp areas, and travel trails, and can be used to examine changes in the use of the landscape over time (see Brody 1988; Weinstein 1992).

Field Trips and On-the-Land Participation

Field trips and participant observation are important methods of learning about landscape. A field trip may be a day excursion or encampment with a knowledgeable person or group of knowledgeable people, or it may involve shared activities on the land. Field trips may involve teams of researchers, including perhaps students or community members, and allow some specialization of functions. Some may concentrate on participating in activities or speaking with local teachers, while others may be concerned with photographic or video documentation, taking GPS data, or collecting specimens.

Field trips allow a sense of the context of ethnoecological knowledge about landscape as well as enabling cross-checking and documentation of specific places and of examples of typical ecotopes. In field trips documentation of places, place-kinds, activities, and associated narratives may all be recorded. Associations of place may be linked both to personal life history and to memory of past activities, and to the mythic and moral realms. Such associations may also have significance in the documentation of land rights through records of past and present use. Some types of narratives are specifically associated with place, and may be told only, or most frequently, on the land, in place (e.g., Palmer 2006). It is a real, and often rare, opportunity to record such narratives (assuming it is considered appropriate in the context of the research project) and here audio or video recording on site can be invaluable.

Plot Studies, Remote Sensing, and Specialized Approaches to Vegetation and Resources

Plot studies are one field method of investigating the nature and knowledge of vegetation communities. Researchers typically work together with local people who have knowledge of the plants and other aspects of the local region to scientifically sample the plants present in a plot of specific area, recording ecological data such as special names, locations, and other plant data, together with local knowledge of names and uses of species found within the plot and local classification of the site type. Studies by Bernstein et al. (1997), Ellen (2007), and Paul Sillitoe (1996) demonstrate the effectiveness of plot study methods. Related work by Shepard et al. (2002), Abraao et al. (2010), and Shepard et al. (2004) shows how plot studies can be combined with techniques of ordination, and comparison with vegetation stratification through remote sensing.

REFERENCES

- ABRAÃO MB, SHEPARD GH JR, NELSON BW, BANIWA JC, ANDRELLLO B, YU DW. Baniwa vegetation classification in the white-sand *campinarana* habitat of northwest Amazon, Brazil. In: JOHNSON LM, HUNN ES, editors. Landscape ethnecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 83–115.
- ADELAAR S. Orientation systems in Western Austronesian Languages. Anthropology Seminar, University of Alberta, 20 March; 2000.
- ALKIRE WH. Marine exploitation on Woleai and Lamotrek Atolls, Micronesia: conservation, redistribution and reciprocity. Paper presented at Chacmool Conference, Calgary, Alberta; 1991.
- ANDERSON D. Identity and ecology in Arctic Siberia: the number one reindeer brigade. Oxford: Oxford University Press; 2000.
- ANDERSON EN. Managing Maya landscapes: Quintana Roo, Mexico. In: JOHNSON LM, HUNN ES, editors. Landscape ethnecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 255–276.
- APORTA C. Life on the ice: understanding the codes of a changing environment. *Polar Rec* 2002;38(207):341–354.
- APORTA C. Life on the ice: understanding the codes of a changing environment. In: JOHNSON LM, HUNN ES, editors. Landscape ethnecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 175–199.
- ATLAN S. Itza Maya tropical agro-forestry. *Curr Anthropol* 1993;34(5):633–700.
- BANDEIRA FPS DE F, BLANCO JL, TOLEDO VM. Tzotzil Maya ethnecology: landscape perception and management as a basis for coffee agroforest design. *J Ethnobiol* 2002;22(2):247–272.
- BASSO K. Stalking with stories: names, places and moral narratives among the Western Apache. In: *Western Apache Language and Culture*. Tucson: University of Arizona Press; 1990a. p 98–137.
- BASSO K. Speaking with names: language and landscape among the Western Apache. In: *Western Apache Language and Culture*. Tucson: University of Arizona Press; 1990b. p 138–173.
- BASSO K. Wisdom sits in places. Landscape and language among the Western Apache. Albuquerque: University of New Mexico Press; 1996.
- BASTIEN J. Mountain of the Condors, metaphor and ritual in an Andean ayllu. St. Paul (MN): West Publishing; 1978.
- BEAUCAGE P. Taller de Tradición Oral del CEPEC. Integrating innovation: the traditional Nahua coffee-orchard (Sierra Norte de Puebla, Mexico). *J Ethnobiol* 1997;17(1):45–67.
- BENDER B, editor. Landscape, politics and perspectives. Oxford: Berg; 1993.
- BENDER B, editor. Time and landscape. *Curr Anthropol* 2002;43(Suppl):103–112.
- BENDER B, WINER M, editors. Contested landscapes: movement, exile, and place. Oxford and New York: Berg; 2001.
- BERNSTEIN JH, ELLEN R, BIN ANTARAN B. The use of plot surveys for the study of ethnobotanical knowledge: a Brunei Dusun example. *J Ethnobiol* 1997;17(1):69–96.
- BERKES F. Sacred ecology. New York: Routledge; 2008.
- BERKES F, COLDING J, FOLKE C. Navigating social–ecological systems: building resilience for complexity and change. Cambridge: Cambridge University Press; 2003.
- BERKES F, KISLALIOGLU M, FOLKE C, GADGIL M. Exploring the basic ecological unit: ecosystem-like concepts in traditional societies. *Ecosystems* 1998;1(5):409–415.
- BRODY H. Maps and dreams, Indians and the British Columbia frontier. Vancouver/Toronto: Douglas and McIntyre; 1988.
- CLÉMENT D. The historical foundations of ethnobiology. *J Ethnobiol* 1998;18(2):161–187.
- COLLIGNON B. Knowing places, the Inuit, landscapes and the environment (trans. MÜLLER-WILLE LW). Edmonton: Canadian Circumpolar Institute (CCI) Press; 2006.
- DAVIDSON-HUNT I, BERKES F. Learning as you journey: Anishinaabe perception of social–ecological environments and adaptive learning. *Conserv Ecol* 2003;8(1). Available at <http://www.ecologyandsociety.org/vol8/iss1/>.
- DAVIDSON-HUNT I, BERKES F. Journeying and remembering: Anishinaabe landscape ethnecology from Northwestern Ontario. In: JOHNSON LM, HUNN ES, editors. Landscape ethnecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 222–240.
- ELLEN RF. Local and scientific understandings of forest diversity on Seram, Eastern Indonesia. In: SILLITOE P, editor. Local science vs global science: approaches to Indigenous knowledge in international development. Oxford: Berghahn; 2007.
- ELLEN RF. Why aren't the Nuaulu like the Matsigenka? Knowledge and categorization of forest diversity on Seram, Eastern Indonesia. In: JOHNSON LM, HUNN ES, editors. Landscape ethnecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 116–140.
- FORD RI. The nature and status of ethnobotany (2nd edition). Anthropological Papers, Museum of Anthropology University of Michigan No. 67. Ann Arbor: Anthropology Museum, University of Michigan; 1994.
- FORMAN RTT. Interaction among landscape elements: a core of landscape ecology. In: TJALLINGII SP, DE VEER AA, editors. Perspectives in landscape ecology, contributions to research, planning, and management of our environment. Wageningen: Centre for Agricultural Publishing and Documentation; 1982. p 35–48.
- FOWLER CS. What's in a word? Southern Paiute place names as keys to environmental perception. In: JOHNSON LM, HUNN ES, editors. Landscape ethnecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 241–254.

- FREEMAN M, editor. Inuit land use and occupancy project. A report. 3 volumes. Ottawa: Ministry of Supply and Services; 1976.
- GILMORE MP. An ethnoecological and ethnobotanical study of the Majjuna Indians of the Peruvian Amazon [unpublished PhD Dissertation]. Oxford (OH): Miami University.
- GILMORE MP. The cultural significance of the habitat *mañaco taca* to the Majjuna of the Peruvian Amazon. In: JOHNSON LM, HUNN ES, editors. Landscape ethnoecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 111–158.
- GLADWIN T. East is a big bird, navigation and logic on Pulauwat Atoll. Cambridge: Harvard University Press; 1970.
- GOODENOUGH W. Navigation in the Western Carolines, a traditional science. In: NADER L, editor. Naked science: anthropological inquiry into boundaries, power, and knowledge. New York: Routledge; 1996. p 29–42.
- GOW PL. Land, people and paper in western Amazonia. In: HIRSCH E, O'HANLON M, editors. The anthropology of landscape: perspectives on space and place. Oxford: Clarendon Press; 1995. p 43–62.
- Gwich'in Social and Cultural Institute. Place name map. Peel River #21. Available at <http://www.gwichin.ca/Research/placeNamePeel.asp?num=21>. Accessed 2009 June 8.
- HIRSCH E, O'HANLON M, editors. The anthropology of landscape: perspectives on space and place. Oxford: Clarendon Press; 1995.
- HUMPHREY C. Landscape conflicts in Inner Mongolia: walls and cairns. In: BENDER B, WINER M, editors. Contested landscapes: landscapes of movement, exile, and place. Oxford and New York: Berg; 2001. p 55–68.
- HUNN ES. Columbia Plateau Indian place names: what can they teach us? *J Ling Anthropol* 1996;6(1):3–26.
- HUNN ES. A Zapotec natural history: trees, herbs, and flowers, birds, beasts, and bugs in the life of San Juan Gbëë. Tucson: University of Arizona Press; 2008.
- HUNN ES, MEILLEUR BA. Toward a theory of landscape ethnoecological classification. In: JOHNSON LM, HUNN ES, editors. Landscape ethnoecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 15–26.
- HUNN ES, with James Selam and family. Nch'i Wána "The Big River", Mid-Columbia Indians and their land. Seattle: University of Washington Press; 1990.
- INGLIS F. Nation and community: a landscape and its morality. *Sociological Review*, 1977;25:489–514.
- INGOLD T. The temporality of the landscape. *World Archaeol* 1993;25(2):152–174.
- INGOLD T. The perception of the environment: essays in livelihood, dwelling and skill. London and New York: Routledge; 2000.
- ISTOMIN KV, DWYER MJ. Finding the way, a critical discussion of anthropological theories of human spatial orientation with reference to reindeer herders of Northeastern Europe and Western Siberia. *Curr Anthropol* 2009;50:29–50.
- JOHANNES RE. Words of the Lagoon. Berkeley: University of California Press; 1981.
- JOHNSON LM. "A place that's good", Gitksan landscape perception and ethnoecology. *Hum Ecol* 2000; 28(2):301–325.
- JOHNSON LM. Visions of the Land—Kaska ethnoecology, "kinds of place," and "cultural landscape". In: JOHNSON LM, HUNN ES, editors. Landscape ethnoecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 203–221.
- JOHNSON LM. Trail of story, traveller's path: reflections on ethnoecology and landscape. Edmonton: Athabasca University Press; 2010b.
- JOHNSON LM, HARGUS S. Witsuwit'en words for the land — a preliminary examination of Witsuwit'en ethnogeography, pp. 147–157. In TUTTLE S, SAXON L, GESSNER S, BEREZ A, editors. Alaska Native Language Center Working Papers in Athabaskan Linguistics Number 6, November 6, 2006. Fairbanks, Alaska Native Language Center; 2007.
- JOHNSON LM, HUNN ES, editors. Landscape ethnoecology, concepts of physical and biotic space. New York: Berghahn Books; 2010.
- KARI J. Some principles of Alaskan Athabaskan toponymic knowledge. In: KEY MR, HOENIGSWALD HM, editors. General and Amerindian ethnolinguistics, in remembrance of Stanley Newman. Berlin and New York: Mouton de Gruyter; 1989. p 129–149.
- KARI J, FALL J. Shem Pete's Alaska, the territory of the Upper Cook Inlet Dena'ina. Fairbanks: Alaska Native Language Center, University of Alaska; 1987.
- KROHMER J. Umweltwahrnehmung und -klassifikation bei Fulbegruppen in verschiedenen Naturräumen Burkina Faso und Benins (Westafrika) [dissertation]. Faculty of Biology, Goethe-University Frankfurt; 2004. Available at <http://publikationen.uni-frankfurt.de/volltexte/2005/508>.
- KROHMER J. Landscape perception, classification and use among Sahelian Fulani in Burkina Faso (West Africa). In: JOHNSON LM, HUNN ES, editors. Landscape ethnoecology, concepts of physical and biotic space. New York: Berghahn Books; 2010. p 49–82.
- KUNSTADTER P. Ecological modification and adaptation: an ethnobotanical view of Lua' swiddens in northwestern Thailand. In: FORD RI, editor. The nature and status of ethnobotany. 2nd ed. Museum of Anthropology nr 67. Ann Arbor: University of Michigan; 1994. p 169–200.
- LEGAT A, ZOE SA, CHOCOLATE M. Tj̄ch̄o Nd̄e: The importance of knowing. Report prepared by Dene Cultural Institute for the Dogrib Treaty 11 Council and BHP Diamonds Inc. Hay River (NT): Dene Cultural Institute; 1995.
- MCGARIGAL K. NRS 223 website: excerpts from background material to FRAGSTATS. Available at <http://www.edc.uri.edu/nrs/classes/nrs223/readings/fragstatread.htm>.
- MAFFI L. Domesticated land, warm and cold: linguistic and historical evidence on Tzeltal Maya ethnoecology. In: GRAGSON TL, BLOUNT BG, editors. Ethnoecology: knowledge, resources, rights. Athens: University of Georgia Press; 1999. p 41–56.

- MAFFI L, editor. *On biocultural diversity, linking language, knowledge and the environment*. Washington (DC) and London: Smithsonian Institution Press; 2001.
- MARK DM, TURK AG. Landscape categories in Yindjibarndi: ontology, environment, and language. In: KUHN W, WORBOYS M, TIMPF S, editors. *Spatial information theory: foundations of geographic information science*. Lecture Notes in Computer Science. Dordrecht: Springer-Verlag; 2003. p 31–49.
- MARK D, TURK A, STEA D. Ethnophysiography of arid lands: categories for landscape features. In: JOHNSON LM, HUNN ES, editors. *Landscape ethnecology, concepts of physical and biotic space*. New York: Berghahn Books; 2010. p 27–45.
- MARTIN G. Ecological classification among the Chinantec and Mixe of Oaxaca, México. *Etnoecológica* 1993; 1(2):14–31.
- MEILLEUR B. The structure and role of folk ecological knowledge in Les Allues, Savoie (France). In: JOHNSON LM, HUNN ES, editors. *Landscape ethnecology, concepts of physical and biotic space*. New York: Berghahn Books; 2010. p 159–174.
- MONTI LS. *Seri Indian adaptive strategies in a desert and sea environment; three case studies: a navigational song map in the Sea of Cortés; the ironwood tree as habitat for medicinal plants; Sonoran Desert plants adapted to treat diabetes* [PhD dissertation]. Tucson: University of Arizona; 2002.
- MONTI LS. *The songs of San Esteban. A navigational song voyage in the Sea of Cortez* (audio recording). Washington (DC): Amazon Conservation Team; 2003.
- MÜLLER-WILLE L. Place names, territoriality and sovereignty: Inuit perception of space in Nunavik (Canadian Eastern Arctic). *Schweiz Amerikanisten-Gesellschaft Bull* 1993;53–54(1989–1990):17–21.
- MULRENNAN M, SCOTT C. Reconfiguring Mare Nullius: Indigenous sea rights and the divergence of domestic and international norms. In: BLASER M, DE COSTA R, COLEMAN W, eds. *Indigenous peoples and autonomy: insights for a global age*. Vancouver: University of British Columbia Press; 2010.
- NELSON R. *Hunters of the Northern ice*. Chicago (IL) and London: University of Chicago Press; 1969.
- NELSON RK. *Make prayers to the raven, a Koyukon view of the Northern Forest*. Chicago (IL): University of Chicago Press; 1983.
- OLWIG KR. Recovering the substantive nature of landscape. *Ann Am Assoc Geogr* 1996;86(4):630–653.
- PALMER AD. *Maps of experience, the anchoring of land to story in Secwepemc discourse*. Toronto: University of Toronto Press; 2006.
- PENTLAND DH. Cartographic concepts of the Northern Algonquians. *Can Cartogr* 1975;12(2):149–160.
- PFISTER RD, ARNO SF. Classifying forest habitat types based on potential climax vegetation. *Forest Sci* 1980;26:52–70.
- POSEY DA. *A preliminary report on diversified management of tropical forest by the Kayapo Indians of the Brazilian Amazon*. In: PRANCE F, editor. *Advances in Economic Botany*. Volume 1. New York: New York Botanical Garden; 1984. p 112–116.
- RODMAN MC. Empowering place: multilocality and multivocality. In: LOW SM, LAWRENCE-ZÚNIGA D, editors. *The anthropology of space and place. Locating culture*. Cambridge: Blackwell Publishing; 2003. p 204–223.
- SABO G. Ethnobiological symbolism in Ozark rock art. Paper presented at 2008 Society of Ethnobiology Annual Conference, Fayetteville, 16 April. University of Arkansas; 2008.
- SAUER CO. *The morphology of landscape*. *Univ Calif Pub Geogr* 1925;2(2):19–54.
- SCHREYER C. Marking space, making place: Taku River Tlingit First Nation's marking of their traditional territory. Paper presented at CSA-CCI Northern Research Day, 11 April. Edmonton: University of Alberta; 2006.
- SHEPARD GH JR, YU DW, LIZARRALDE M, ITALIANO M. Rain forest habitat classification among the Matsigenka of the Peruvian Amazon. *J Ethnobiol* 2001;21(1):1–38.
- SHEPARD GH JR, YU DW, NELSON B. Ethnobotanical ground-truthing and forest diversity in the Western Amazon. In: CARLSON TJS, MAFFI L, editors. *Ethnobotany and conservation of biocultural diversity*. *Advances in Economic Botany* 15. Bronx: New York Botanical Garden Press; 2004. p 133–171.
- SILLITOE P. *A place against time: land and environment in the Papua New Guinea Highlands*. Amsterdam: Harwood Academic Publishers; 1996.
- STAPP JR, WYNDHAM FS, ZARGER R, editors. *Ethnobiology and biocultural diversity*. Athens (GA): International Society of Ethnobiology; 2002.
- STRANG V. *Uncommon ground, cultural landscapes and environmental values*. Oxford and New York: Berg; 1997.
- Taller de Tradiccion Oral del CEPEC and Pierre Beaucage. *La bonne montagne et l'eau malfaisante. Toponymie et pratiques environnementales chez les Nahuas de basse montagne (Sierra Norte de Puebla, Mexique)*. *Anthropol Soc* 1996;20(3):33–54.
- TANSLEY A. *The British Isles and their vegetation*. Cambridge: Cambridge University Press; 1939.
- THORNTON T. *Anthropological studies of Native American place naming*. *Amer Ind Quart* 1997;21(2): 209–228.
- THORNTON T. *Being and place among the Tlingit*. Seattle: University of Washington Press; 2008.
- TILLEY C. *A phenomenology of landscape, places, paths and monuments*. Oxford: Berg; 1994.
- TOBIAS TN. *Chief Kerry's moose, a guidebook to land use and occupancy mapping*. Research design and data collection. B.C. Union of Indian Chiefs and Ecotrust Canada; 2000.
- TOLEDO VM. What is ethnecology? Origins, scope and implications of a rising discipline. *Etnoecológica* 1992;1(1):5–21.

- TOLEDO VM. Ethnoecology: a conceptual framework for the study of Indigenous knowledge of nature. In: J. R. STEPP F, WYNDAM S, ZARGER RK, editors. *Ethnobiology and biocultural diversity*. Athens (GA): International Society of Ethnobiology; 2002. p 511–522.
- TUAN YI-FU. *Topophilia, a study of environmental perception, attitudes, and values*. Englewood Cliffs (NJ): Prentice-Hall; 1974.
- VITEBSKY P. *The Reindeer People, living with animals and spirits in Siberia*. Boston and New York: Houghton-Mifflin; 2005.
- WEINSTEIN M. *Just like people get lost: a retrospective assessment of the impacts of the Faro Mining Development on the land use of the Ross River Indian people*. Report to the Ross River Dena Council. Ross River, Yukon; 1992.

Chapter 17

Traditional Resource and Environmental Management

CATHERINE S. FOWLER

Department of Anthropology, University of Nevada, Reno, Reno, Nevada

DANA LEPOFSKY

Department of Archaeology, Simon Fraser University Burnaby, BC, Canada

INTRODUCTION	285
DEFINING TRADITIONAL RESOURCE AND ENVIRONMENTAL MANAGEMENT	286
THE HISTORICAL AND SOCIAL CONTEXT OF TREM	287
COMMON PRACTICES	288
BURNING	288
DIGGING AND TILLING	290
PRUNING, COPPICING, AND POLLARDING	290
WEEDING AND CLEANING	290
TRANSPLANTING	290
SELECTIVE HARVESTING AND REPLANTING	291
ENCLOSURES	292
MULCHING AND FERTILIZING	292
DOCUMENTING TREM	292
TREM IN CONTEXT	294
THE FUTURE OF TREM	295
REFERENCES	301

INTRODUCTION

Since the mid-1980s, ethnobiologists have focused on documenting Indigenous systems of environmental and resource management, especially among the world's subsistence-based

peoples. Ethnobiologists recognize that groups who earn a living directly from their surroundings have significant, long-term knowledge about their environments and the resources within them. This ecological knowledge along with attendant procedures for working with local resources is not only of interest in and of itself, but because it may hold keys to sustainable practices. This local knowledge is held by individuals, collectively by families, and by communities. It can be expressed overtly through practices that are mandated through political or religious requirements, or more covertly codified in general attitudes and casual acts that affect everyday behavior.

In this chapter, we explore ways in which peoples tend, steward, or otherwise manage their environments and resources and how ethnobiologists study and document these activities. We look at examples of activities still in practice, some from the recent past, and some from the distant past as revealed primarily through archaeology. Our examples are primarily North American because we are most familiar with that literature, but the practices and knowledge we discuss have been applied in similar environments worldwide. We refer to these activities and knowledge collectively as “traditional resource and environmental management” (TREM). *TREM is defined as the application of traditional ecological knowledge to maintain or enhance the abundance, diversity, and/or availability of natural resources or ecosystems.*

We discuss common practices for managing plants and animals: burning, tillage and other methods of soil enhancement, pruning, weeding, transplanting, selective harvesting and replanting, and enclosures. We focus on the management of non-domesticated plants and animals. However, since human–landscape interactions form a continuum from casual management to highly intensive agro-ecosystems, many practices we discuss are common to a wide range of subsistence strategies.

DEFINING TRADITIONAL RESOURCE AND ENVIRONMENTAL MANAGEMENT

Many concepts, terms, and acronyms are used in discussions about TREM (see M.K. Anderson 2005; Deur and Turner 2005a; Menzies 2006, for sample bibliographies). The concept that underlies and links all aspects of these practices is “traditional ecological knowledge” (TEK). TEK is formally defined as “a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations, by cultural transmission about the relationship of living beings (including humans) with one another and with their environment” (Berkes 2009: 8). Importantly, ecological knowledge, including that of managing land and resources, is based on direct observations of and interactions with an environment. This knowledge developed over time, and was passed down through the generations. TEK typically refers to knowledge held by non-industrial (often called traditional) peoples who observe and participate daily in the workings of their environments. However, it can also be applied to ecological knowledge held by local peoples who are modern farmers and ranchers. It is ecological knowledge about a particular environment and its resources that becomes the basis for traditional resource management systems.

Many scholars have pointed out differences between traditional (TEK and TREM) and Western scientific ways of viewing the natural world (Anderson 1996; Berkes 2009; Turner et al. 2000; but see Lertzman 2009). A fundamental difference is the common Western perception that people are distinct from the natural world, not part of it. Even anthropological and ecological models that include humans in ecosystems sometimes conceptualize human interactions with the environment as distinct from other life forms (Crumley 1994; Moran 1996). This Western worldview stands in sharp contrast to that of many

Indigenous peoples, who see non-human life forms as family members who, like all kin, should be treated properly and respectfully (Atleo 2005; Ellen and Fukui 1996). From this more integrated perspective, interactions with the natural world, for example, “managing resources”, cannot easily be separated from cultural beliefs and practices (M.K. Anderson 2005; Cruikshank 2005; Turner et al. 2000). To separate and compartmentalize is to lose track of the interconnections, of the true and comprehensive ecosystems, and what E. Anderson (1996) calls “ecologies of the heart”.

Some have argued that discussing management practices as mechanical, discrete acts is antithetical to the spirit of what traditional peoples do and feel. “Management” can misrepresent Indigenous attitudes in that it implies “control” over resources and lands that they do not conceive. Several researchers have suggested that terms such as “stewardship”, “custodianship”, or “husbandry/wifery” better capture the nature of these Indigenous systems, and that instead of management, “tending”, “caring for”, “taking care of”, “working with”, or like forms are better descriptors of Indigenous attitudes and practices (M.K. Anderson 2005; Atleo 2005; Nabhan 1997).

TEK and TREM can have great time depth, but are by no means static. Ecological knowledge can change as other aspects of cultures and their environments change. It is for this reason that ecological knowledge embodied in TREM can be applied in today’s contexts, and that documenting currently held ecological knowledge and management strategies helps us understand past human–environmental relations.

THE HISTORICAL AND SOCIAL CONTEXT OF TREM

Outside observers have long misunderstood the relationship of Indigenous peoples to their environments. Misconceptions have become reified over time, and used to justify the appropriation of land and other rights from Indigenous peoples (Deur and Turner 2005b). There are three archetypical views about how traditional peoples interact with their environments: (1) they have few or no interactions with or impact on their surrounding environments; (2) they are responsible for severe environmental degradation worldwide; or (3) they live in ecological balance with their surroundings by consciously practicing resource management and conservation.

The view that Indigenous peoples had little interaction with their environment is pervasive in the earliest encounters between Europeans and Indigenous peoples (Denevan 1992). In Polynesia, for instance, Europeans felt that they were witnessing Edenic perfection, where environments were ever-bountiful and required little human manipulation (Lepofsky 1999). In reality, the islands were highly managed agroecosystems; the “natural” bounty was the result of centuries of human landscape manipulation (Lepofsky 2011). However, because management systems had few parallels in Europe, managed land and seascapes were seen as natural. Such early misconceptions have left a legacy of assumptions about human–environment interactions, which influence how we conceptualize and manage “wilderness” today (Cronon 1995; Hunn et al. 2003).

Other discussions of human–environmental interactions focus on whether Indigenous peoples were degraders or adept managers of land and resources (Ellen and Fukui 1996; Harkin and Lewis 2007). Support for the former view comes largely from archaeological and paleoecological records, which document dramatic and sometimes devastating human-caused alterations to the landscape (Diamond 2005; Kirch and Hunt 1997). Support for the adept manager model largely comes from ethnobiologists working closely with Indigenous communities who know how to manage and enhance biological productivity and diversity (Balée and Erickson 2006).

When the data are considered dispassionately, it is clear that none of the three models is entirely true. Although there is a continuum of intensity of how peoples interact with their environment, many traditional peoples have had intensive interaction with their surroundings. Furthermore, even within a cultural group, people are neither exclusively degraders nor completely effective managers. This is reflected in the archaeological record which provides examples not only of human-caused ecological “damage”, but also long-term management of resources and landscapes. In fact, environmental depletion may be linked to the development of TREM among some people (Berkes and Turner 2006). To some extent, many archaeologists have operated under a paradigm of “degradation” rather than effective management, and may have overlooked subtle evidence of past resource management (Ford and Nigh 2009; Weiser and Lepofsky 2009). As ethnobiologists, we need to allow for the full spectrum of potential human interactions with their environments. A solid understanding of the social and ecological contexts of past management successes and failures should provide the knowledge needed to manage our resources today (Hames 2007).

COMMON PRACTICES

Management practices encompassed within TREM are found worldwide and encompass a range of behaviors that are applied to plants and animals, often with predictable ecological consequences (Table 17.1). Practices are most often applied to specific organisms, or populations of organisms, although they may have larger cumulative community effects. These practices are not mutually exclusive and all can be applied at local and landscape scales (M.K. Anderson 2005; Peacock and Turner 2000). Tied to these practices are other inter-related cultural factors such as technology and the frequency, timing, and intensity of practices (M.K. Anderson 2005: 128–34). Many of these factors are interrelated and alterations in one might influence the outcome of another. For example, if a technology becomes more efficient, and the intensity of its related activity is not reduced, the target resource could be overtaxed. Cultural practices, such as religious activities, kinship and political features, and land tenure systems, can also affect land and resource management (see Section 6, below).

Burning

Burning is the best known and most widely applied TREM practice, with some form of fire management occurring worldwide. The regenerative power of landscape fires, although not always immediately apparent, is often visible within months to a year, provided the original fire was not so hot as to damage root stocks or to kill or permanently displace animals. Some burns are large scale, for example in grasslands where they might cover many square miles, but many are smaller—10–50 acres—where they create a patchwork of biodiversity (Fowler 2000; Lewis 1973; Trusler and Johnson 2008). Large-scale fires are set to drive game or to “freshen” or “renew” the country. Renewed growth then attracts more game (see Case Studies 17.1 and 17.2). Until recently, many North American Indigenous peoples burned certain woody perennials to obtain straight, strong fibers for basketry and building, and a long list of annuals and perennials (many pre-adapted to fire) to increase the production of foods (berries, tubers, leafy greens) and medicines (E. Anderson 2005; M.K. Anderson 2005; Hodgson 2000; Turner 1999). Swidden farmers also practice an intensive form of burning in their field preparation (Case Study 17.3). Even when burning targeted local populations of species, such fires could influence biological communities across the landscape.

Table 17.1 Management Practices and their Ecological Effects¹

Management practice	Potential ecological effects ²
Burning	<ul style="list-style-type: none"> • Changes in fire regimes (seasonality, frequency, patch size) reduces competition • Discourages pests • Accelerates nutrient cycling • Blackened ground encourages spring growth • Promotes early successional vegetation and associated animals; selects for annuals and ephemerals • Synchronization of fruiting • Shifts in vegetation mosaics; creates openings • Promotes fire-tolerant, shade-intolerant taxa
Digging and tilling	<ul style="list-style-type: none"> • Dispersal of propagules • Recycles nutrients • Aerates soil • Increases moisture-holding ability • Possible reduction of allelopathy (negative below-ground plant-to-plant interactions)
Pruning	<ul style="list-style-type: none"> • Increase investment in fruit production
Coppicing	<ul style="list-style-type: none"> • Stimulates vegetative reproduction, growth of roots and rhizomes, and flowering and seed production
Weeding and cleaning	<ul style="list-style-type: none"> • Reduces interspecies competition • Allows quicker moisture penetration • Decreases chances or spread of fire
Transplanting	<ul style="list-style-type: none"> • Geographic range extensions • Dispersal of propagules • Establishes new local populations
Selective harvesting and replanting	<ul style="list-style-type: none"> • Changes in plant morphology and genetics • Reduces intraspecies competition • Local dispersal of propagules • Maintains productivity in local populations
Enclosures	<ul style="list-style-type: none"> • Isolates propagules from rest of breeding population
Mulching and fertilizing	<ul style="list-style-type: none"> • Increases soil nitrogen, phosphorous, and other nutrients; increases soil temperature.

¹Modified from Turner and Peacock (2005, and references within) and Lepofsky and Lertzman (2008).

²Only positive ecological effects are listed here, but in some cases there is the potential for negative ecological effects. For instance, whereas burning releases nitrogen into the soil, it can also result in a net loss of nitrogen in the system. Similarly, whereas blackened earth can encourage spring growth, it can overly warm soils in the summer and this may kill plants. Finally, while digging can reduce allelopathic interactions it may also interrupt positive below-ground plant-to-plant interaction.

To minimize destruction and maximize regeneration, fires were set only in particular seasons and intervals. Native Californians (M.K. Anderson 2005), Australians and North American Plains groups (Lewis 1991, 1993) and British Columbian groups (Gottesfeld-Johnson 1994; Lepofsky et al. 2005; Turner 1999) set fires at well timed and ecologically sound intervals—every two to three years—usually just before a period of increased precipitation or marked cooling. Fuel loads are kept low with frequent burning. This reduces high

intensity fires that could damage underground plant parts, and results in fires that can be more easily controlled.

Digging and Tilling

Digging and tilling involve moving soil, rocks, and other debris from an area with important underground resources (plants, burrowing animals). Digging is part of the process of collecting plant foods such as root vegetables, or other underground parts used as medicines or manufactures (e.g., roots, tubers, rhizomes for basketry, lacings). Digging may also extract burrowing animals like ground squirrels or lizards from their dens. Tilling occurs when diggers go beyond these immediate goals and clean or clear beds in preparation for planting seeds or propagules. Digging and tilling are accomplished with simple tools like digging sticks or pry bars, although agriculturalists develop devices such as plows to accomplish larger goals.

Digging and tilling influence the productivity of resources, and in particular increase plant vigor and size by aerating the soil and increasing its moisture-holding capacity. In contrast, unharvested or untended patches become overgrown and underground plant parts become less productive and difficult to harvest. Like burning, tilling attracts game to freshly dug patches, which in turn can provide additional food and resources.

Pruning, Coppicing, and Pollarding

Pruning is the removal of dead and living material from a plant to change its shape or enhance its production. Coppicing is the regular cutting back of growth, usually to ground level, to promote vigorous new growth and secondarily to encourage forage for game. Pollarding refers to the coppicing of trunks, specifically. Coppicing is an age-old woodland management method in Europe, and in North America it is used to obtain desired lengths and strengths of basketry fibers (Barkham 1992; Fig. 17.1). Pruning is also a way to get fuel wood in areas where burnable products are scarce (Case Study 17.2).

Weeding and Cleaning

Weeding involves removing unwanted plants from around valued plants by cutting, pulling, and digging. Weeding has ecological consequences, including reducing competition. In some situations weeding may produce a “first harvest” of edible greens, while in others, weeds may be turned into mulch (Case Studies 17.4 and 17.2). The Kwakwaka’wakw of British Columbia removed grasses, rushes, and sedges from their estuarine root plots, fostering better growth of springbank clover, Pacific silverweed, and other plants, and also protected the plants from herbivory by hunting waterfowl attracted to these lush plots (Case Study 17.4). The application of natural pesticides and companion planting also minimize the growth of unwanted plants and increases productivity of desired ones (Balée 1994).

Transplanting

Transplanting involves purposefully introducing a species from one wild setting and/or habitat to another, often to extend its range or to replenish a depleted population. Translocation of plants is done by sowing seed or other propagules in new places, or by physically moving specimens. For animals, transplanting involves moving at least a breeding pair, and/or eggs in the case of fish. Non-agricultural peoples and subsistence farmers



Figure 17.1 Northern Paiute of Nevada collecting willow for basketry. The main photo shows the trimming and coppicing process while the insert figure is of straight stems collected the following year. Photographs by Margaret Wheat, courtesy of Special Collections, Reno Library, University of Nevada; ca. 1960.

commonly moved plants and animals (Case Study 17.3). For example, the Comcáac, or Seri, of Mexico transplanted saguaro cacti to mark the birthplaces of their children (Felger and Moser 1985). They also moved iguanas and chuckwallas from mainland locations onto the Midriff Islands of the Sea of Cortez (Nabhan 2000).

Transplanting is usually distinguished from non-purposeful range extensions caused by human activities such as accidental transporting or discard of viable plant parts. However, it is sometimes difficult to determine whether disjunct distributions resulted from deliberate or inadvertent human agency. Transplanting has resulted in disjunct plant and animal populations that have long puzzled biogeographers (Nabhan 2000).

Selective Harvesting and Replanting

For varied reasons, traditional peoples often selectively harvest resources for food and manufacturing. Such practices may be coupled with replanting plant parts that are too small or not ready or otherwise suitable for harvest. Age, sex (of animals), condition, abundance of the resource, and gender of the gatherer can guide harvesting choices. Sometimes there are culturally prescribed harvesting formulae (e.g., harvest a maximum number, take every other one, take only at a full moon, never in winter). For example, the Maidu of California cut ponderosa pine roots for baskets from opposite sides of the tree in successive years (M.K. Anderson 2005: 128). At other times, more general principles guide harvesting, such as not taking more than you can use immediately, or never taking all. Rules may extend to replanting small plant bulbs or corms, slips from the root, or part of the crown of a perennial. Nets and other capture devices are sometimes designed to select (and thus regulate) the size class or species of a harvest (Case Study 17.4). Selecting for larger seed size,

synchronous ripening, shattering, and other features were important for plant domestication (Harlan 1995), as were docility, size, and weight for animals (Zeder et al. 2005). In some cases, plant tending and animal harvesting went hand in hand, as is the case with “garden hunting” (Linares 1976).

Enclosures

Enclosures are devices for confining resources, and are generally associated with domestication. However, non-domesticated plants are sometimes contained within structured spaces (gardens), where they are encouraged, including through weeding and mulching (Case Study 17.4). Enclosures for animals include traps and nets, especially those designed to keep the catch alive until it is harvested (Case Study 17.4). An example of such enclosures are the “caterpillar trenches” of the Mono Lake and Owens Valley Paiute peoples. These circular structures around Jeffrey pines trapped caterpillars of the Pandora moth (Fowler and Walter 1986).

Mulching and Fertilizing

The addition of mulch and natural fertilizers to soils increases productivity by adding nutrients and/or increasing soil temperature (Balee 1994). Warmer soils, which are the result of increased biological activity, can extend the growing season (Waddell 1972). Mulch is often composed of kitchen waste and other gathered organics (Case Study 17.4) and applied to tended plants in enclosures or gardens and fields. Among the Ancestral Puebloans of New Mexico, rocks are added to the soil to warm it, prevent weeds, and retain moisture (Ford 2000).

DOCUMENTING TREM

Capturing the holistic nature of TREM systems involves applying diverse methods and approaches (Fig. 17.2; see Martin 1995 and Chapters 5, 9, 11, 16 and 18, 2011). When studying TREM of the present or recent past, ethnobiologists generally collect data through consultant interviews combined with field visits and observations of TREM in action. Field observations are critical because some TREM activities may be so ingrained that people cannot describe them in the abstract. Furthermore, they may not realize that these activities actually constitute “management”, but rather see them in coordination with other aspects of their lives, such as religious observances.

Examining data collected by previous field workers can provide insights into TREM. For example, place names collected long ago can indicate areas where TREM activities took place, or where resources once occurred but are no longer evident (Gottesfeld-Johnson 1994; Hunn 1990; Kari and Fall 2003). Indigenous languages often contain unique vocabulary that refers to TREM practices or anthropogenic landscapes (Norton et al. 1999). Old photographs often show the effects of ecological change such as fire suppression, including in environments that consultants may not remember were burned (Hunn 1990: 130–31). These, as well as early documents (maps, letters, agency reports), sometimes reveal practices that might be part of TREM strategies. Using land surveys prior to non-Indian settlement, Lawton et al. (1976) were able to identify stream capture and diversions by Owens Valley Paiute people. These surveys better documented irrigation of wild plants than did the late 1920s ethnographic interviews. Finally, ethnohistoric

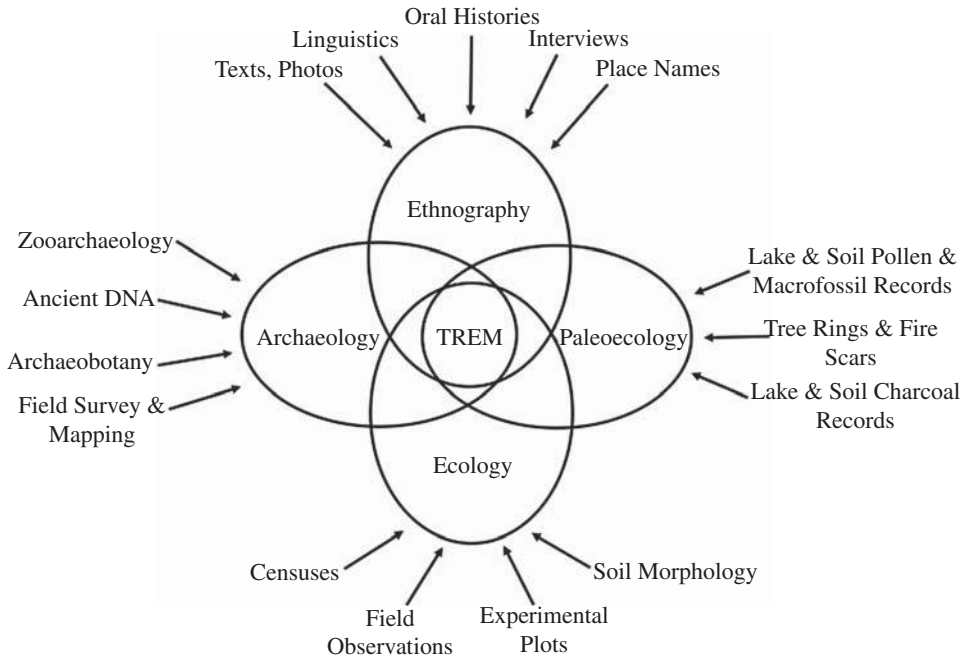


Figure 17.2 Sources of data used to describe TREM systems. See Lepofsky and Lertzman (2008) for more detailed treatment of the archaeological and paleoecological data sources. Modified from Lepofsky and Lertzman (2008).

documents that record observations prior to extensive European contact are valuable sources. However, these sources are sometimes of limited value because many European explorers and settlers failed to recognize traditional management systems for what they were.

Increasingly, ethnobiologists combine ethnographic data with ecological methods to document resource management systems. Researchers use modern plant and animal distributions as evidence of past resource and habitat manipulation and range extensions (Deur 1999, 2000). Soil analyses allow assessment of the ecological effects of practices such as mulching and tilling. Ethnobiologists also use knowledge from elders to design field experiments to quantify changes in resource abundance and distribution under traditional management (Beckwith 2004). Such experiments can provide the ecological details needed to incorporate traditional management methods into modern management regimes.

Although less often applied, archaeological and paleoecological methods have a considerable amount to offer to the documentation of TREM (Lepofsky and Lertzman 2008). Since traditional management systems evolved through time, changing as social and political contexts changed, we cannot simply record present or remembered systems and expect to understand these changes. Furthermore, given the dramatic alterations in natural and cultural landscapes since the industrial era, and losses in Indigenous knowledge, archaeological or paleoecological studies may be the only way to document many past management systems.

Archaeological and paleoecological records can provide insights into past human manipulation and landscape management (see Chapter 11, 2011). These records can document fires or other disturbances that occurred more frequently than expected from natural causes, and fires that occurred outside naturally fire-prone ecosystems or fire seasons. Pollen, zooarchaeological, and paleoethnobotanical evidence of non-local species can

provide evidence of transplanting or tending of taxa outside their natural distributions, whereas changes in morphology, genetics, or abundance in archaeological plant or animal remains can provide evidence of selective harvesting and methods to enhance production. Finally, archaeological features such as garden plots and terraces can provide information on the nature and extent of ancient landscape modifications.

However, there are limitations on the inferences about past management that can be drawn from archaeological and paleoecological records. First, many traditional management practices to some extent mimic natural ecological processes and/or were designed to minimize excessive disturbances. Thus, it can be difficult to detect ancient management practices in archaeological and paleoecological records or to distinguish management from natural processes (e.g., natural versus human-set fires where natural fire frequencies are very high; Lepofsky et al. 2005).

Secondly, it may be difficult to determine whether observed past ecological changes were the result of deliberate or inadvertent human actions. That is, in studying TREM, we are often interested in how people used their ecological knowledge to interact purposively with their environment. However, we may never be able to determine if, for instance, disjunct distributions of economically important plants are the result of deliberate or inadvertent human transport (Minnis and Plog 1976).

The final set of reasons limiting inferences about past resource management relates to limitations of archaeological and paleoecological determinations more broadly. These methods will generally be biased towards recording significant ecological changes and landscape modifications, and long-term human behavior. Conversely, the record will be largely silent about the actions of individuals, or the less tangible aspects of TREM, such as detailed ecological knowledge, rituals, and attitudes toward the natural world.

TREM IN CONTEXT

For most people, TREM is made up of the routine activities of daily life. Occasionally other purposeful acts are involved, such as burning not associated with harvesting, or building enclosures, but much TREM is not so consciously scheduled. Given that these activities reach back many generations, and specific motivations may be lost in time, some people continue their routines without much thought (Berkes and Turner 2006). What may guide activities is a general ethic that can be voiced, such as the Timbisha Shoshone who say “we live by them”, implying the reciprocal obligations that people have with their lands and resources (Case Study 17.2). Older Timbisha people also monitor bird songs, look for new seedlings, and check on the young of animals as signs of environmental health. When harvests are scarce, they, like many traditional peoples, look to internal causes, such as breaking religious or societal rules, rather than external explanations.

There are also examples of TREM activities that are more deeply imbedded in religion and ritual calendars. Among the Pueblo peoples of the American Southwest, the ritual calendar controls many activities associated with plants and animals. Plants and animals have symbolic roles in kinship and are frequently depicted in dances, songs, prayers, oral tradition, and on ritual objects (Robbins et al. 1916; Whiting 1934). Messages about them are communicated in informal and formal settings, absorbed by children, and reinforced in adults. E. Anderson (1996) provides additional examples and an amplified discussion of the role of religion in environmental management and resource conservation in China, Mexico, and the Northwest Coast. He argues not only for religion’s significant role in

guiding behavior but also in providing people with the emotional investment to sustain these practices in the face of modernization and culture change.

Although not separated from religion in many areas, political control in the form of direct leadership and land tenure practices (boundary marking) can also be important forces influencing TREM. On the Northwest Coast of North America, leaders of kin groups and local village chiefs had the power to enforce food collecting regulations for individuals or kin groups, or to exclude groups from certain areas (Turner et al. 2005). Similarly, in Micronesia and elsewhere in the Pacific, reef and lagoon resources were conserved through tenures that prevented outsiders from fishing without permission (Johannes 1981: 64). Elite-imposed restrictions on harvests (e.g., the *rahui* of the Society Islands), or religious prohibitions such as those against entering “sacred groves” (Alcorn 1984) are other examples of socially or politically sanctioned rules that control harvests.

THE FUTURE OF TREM

Today, as in the past, a variety of social and ecological contexts influence whether human interactions with their environments are responsible or positive. Past and present records are replete with examples where the tolls of resource exploitation far outweigh the positive benefits of management practices. In some cases, restrictions by the ruling class are responsible for preventing people from applying ecological knowledge to management, to the detriment of the environment (Crumley 2000; Jones et al. 2008; Rosen 1995). In other cases today, age-old management systems no longer “work” because of changes in the environment, population, or technology (E. Anderson and Medina Tzuc 2005; Shackleton 1993), or TREM practices have been forgotten due to modernization and displacement.

In many societies, however, such ecological knowledge is vitally alive and people are attempting to put it back into practice (M.K. Anderson 2005; Fowler et al. 2003). Since TREM systems are based on long-term, local ecological knowledge, they provide insights on what practices are most effective in given settings, and what environmental conditions existed prior to extensive transformations in the industrial era. Some have worried that bringing TEK to modern management situations, removed from the cultural system in which it developed, can fundamentally change the holistic nature of TREM (Nadasdy 1999). Conversely, Western scientists have sometimes had difficulty with the less tangible, ethical, or spiritual aspects of TREM. However, despite these potential stumbling blocks, many researchers are working successfully with Indigenous and local ecological knowledge-keepers to understand past TREM systems, in order to bring aspects of TREM into current resource management (Ford and Martinez 2000; MacDougall et al. 2004). Clearly, we have much to learn from the cumulative knowledge on which TREM systems are based, and it is in all our best interests to incorporate this knowledge into the management of resources today.

CASE STUDY 17.1 *Managing Intertidal Ecosystems on the Northwest Coast*

Dana Lepofsky and Douglas Deur

At the time of European contact in the late eighteenth century, Northwest Coast peoples had one of the highest population densities in North America (Ames and Maschner 1999). These large populations

of complex hunter-fisher-gatherers actively managed particular resources and habitats to enhance the abundance and diversity of culturally preferred resources (Deur and Turner 2005a; Turner 2005). Such practices were embedded within a larger system of knowledge and beliefs about the ecological and spiritual worlds (Berman 2000; Turner 2005). These practices and knowledge are documented most clearly in the ethnographic record. However, it is becoming increasingly clear that management practices have a long time depth in this region (Deur and Turner 2005a; Weiser and Lepofsky 2009). The compiled evidence suggests that much of the late eighteenth and early nineteenth century landscape represented a mosaic of highly managed ecosystems, purposively modified to enhance the production of valued resources.

In the mid-coast region of the Northwest Coast, home to the Northern Coast Salish and Wakashan speaking peoples such as the Kwakwaka'wakw (or "Kwakiutl"), the maritime foreshore (estuarine to the rocky intertidal zones) was a continuum of intensively managed habitats. Beginning in the middle to upper estuarine zone salt marshes, people maintained family-owned "root gardens" where they enhanced the productivity of four valued native root foods: Pacific silverweed, springbank clover, Nootka lupine, and northern riceroot lily. Root food productivity was enhanced through selective harvesting, replanting, transplanting, weeding, mulching, and tilling (Deur 2005). Constructed rock walls on the downslope side of salt marshes were filled with soil and mulch, thus extending the area that could be cultivated. Place names and oral traditions refer to these cultivated plots, reflecting the extent to which this complex management system was integrated into the larger cultural tradition. Dating the estuarine gardens is difficult, but Deur's (2005) dating of associated anthropogenic soils suggests the gardens are pre-contact in age.



Figure 17.3 Aerial photograph of the intertidal resource management feature in Northern Coast Salish territory taken at an extreme low tide. This feature combines various management elements and illustrates part of the continuum of TREM on the Northwest Coast. The beach has been cleared of cobbles to create a more productive clam habitat and walls were created with these cobbles to extend the suitable clam habitat seaward. On the right side of the photo, cobbles are used to create walls of a small fish trap. This trap would have functioned by catching fish on an incoming or outgoing tide, when water moves through the area rapidly. At the margin of the forest, the cobbles have been cleared away in a small path to create a canoe skid. In the forest is a small archaeological site composed of shellfish and fish collected from these features. A clam shell from the base of this archaeological site was radiocarbon dated to between AD 1540 to 1820. The width of the cleared beach is approximately 20 m. Photograph by Georgia Combes, used with permission. (See color insert.)

Continuing seaward to the upper and mid-intertidal zone, people constructed stone and wooden fish traps (Mobley and McCallum 2001; Fig. 17.3). Although there are many forms—and they likely had multiple functions—these features were often designed to capture fish (and their prey) that swam in at the high tide and then were stranded when the water receded. Some features were designed to keep fish between tides to be harvested when needed and others, by creating suitable habitats, likely increased the abundance and diversity of other marine foods (e.g., clams). Herring and salmon were targeted species of many features, and this is reflected in their design and location (Caldwell 2008; White 2006). Importantly, in contrast to the current industrial practice of catching pre-spawn herring for their roe, herring were traditionally caught after spawning, in part to insure harvest sustainability (Michele Washington, pers. commun.). Fish traps were situated with precise attention to the tidal cycle and stream flows during peak fish runs. Historically, many such features were owned and managed by household heads (Boas 1966: 36; Suttles 1987: 20; White 2006). Most of the mid-coast features are undated, but based on work elsewhere, many should date to some 2000 years ago (Moss and Erlandson 1998; Moss et al. 1990). This sustainable, highly productive traditional fishery stands in dramatic contrast to now threatened modern industrial fisheries of the region.

At the lowest points in the intertidal zone, people maintained highly productive “clam gardens” (Deur 2000; Williams 2006; Woods and Woods 2005). Located on natural clam beaches, rock walls were sometimes formed by moving rocks on the beach seaward. In other cases, the beaches were simply cleared of rocks and no walls were formed (Emily August, pers. commun.; Caldwell et al., in press). Clearing the beaches of rocks increased the area for clams. Like the estuarine gardens, rock abutments on the downslope side of the clam beds served to trap sediment and extend the natural clam habitat seaward. Similarly to the root gardens, clam productivity (probably due to increased recruitment of young) seems to have benefited from the constant working of the beach with digging sticks during harvests, which aerated the clam flats, removed obstructions, and kept the soil matrix pliable. Clam gardens in Kwakwaka’wakw territory were owned and maintained by family groups who were tied to specific winter villages (Chief Adam Dick, pers. commun.). These features have not yet been dated directly, but based on other cultural developments the majority likely date to within the last 2000–3000 years.

CASE STUDY 17.2 *Australian Aborigine Fire Stick Hunting and Farming: The Creation of a Productive Landscape*

Although the cultural and natural landscapes of Australia are diverse, they are united by one basic element—fire. Australia is a mosaic of grasslands and wet and dry forests composed of fire-dependent species, which rely on lightning and human-set fires. For Aboriginal hunter-gatherers, fire was the tool to help hunt game and to increase plant food production. Fire also was, and is, the tool that allows Aboriginal peoples to fulfill their obligation of managing and caring for the land (Fig 17.4; Head 1994; Pyne 1991). The importance of fire was re-affirmed and rekindled over the millennia through daily practice, oral traditions, and rituals (Hallam 1975; Pyne 1991).

Pollen and charcoal records allow paleoecologists to track the long-term effects of fire and the role of humans in this fire-climax land. However, difficulties in distinguishing between natural (lightning) and cultural ignition of fires in the paleoecological record complicate documenting management practices that use fire (Head 2000; Kershaw et al. 2002). Paleoecological records demonstrate that fire was important in the ecology of Australian grasslands and forests long before the arrival of Aboriginal peoples some 50,000 years ago (Kershaw et al. 2002; Pyne 1991). Since settlement, the association of humans with fires is clear, but the specific role of human-set fires in transforming landscapes is difficult to tease out (see review in Pyne 1991).

Despite these difficulties, there is little doubt that ancestral Aboriginal Australians extensively used fire to even out highly seasonal natural burns. Using a fire brand, or “firestick”, Aboriginal peoples set controlled fires both to hunt and to manage the life cycles of plant foods. “Firestick hunting” (Jones



Figure 17.4 Australian Aboriginal women, Kiwirrkurra, burning grasslands to hunt goanna lizards, 2002. Insert: lighting fire (see smoke column in background); the main picture is dinnertime camp the same day in the burned area. Photographs by Laurie Walsh, used with permission. (See color insert.)

1969) was used to flush game such as kangaroos, to clear ground to track lizards (goanna), and to attract kangaroos, emu, and other game to new growth and open habitats (Bird et al. 2005; Pyne 1991). Firestick farming and continual digging enhanced the growth and production of plants, especially those with underground storage organs such as sedges, cycads, and brackens (Gott 2005; Pyne 1991). These resources were harvested during a highly mobile seasonal round. Frequent, low intensity fires enhanced plant production by recycling nutrients, reducing competing vegetation, encouraging post-fire colonizers, and sometimes by synchronizing ripening times (Kohen 2003; Pyne 1991).

Anthropogenic fires were prescribed in space and time depending on fuel availability, precipitation, and the effect on valued resources. In forested regions, fire cycles began at the end of the wet season and continued throughout the dry season for up to 10 months (Hallam 1975; Pyne 1991). Areas were burned every one to four years, depending on the ecosystem. In fuel-limited central deserts, however, fires were much more infrequent. In some regions, fires were prescribed because of the potentially devastating effects of burning on plant resources. Such areas were protected by firebreaks and prohibitions involving spirits. Wasteful fires were also prohibited, with prohibitions reinforced through oral traditions about the Dreamtime (Pyne 1991).

Aboriginal peoples' knowledge of fire ecology co-evolved with Australia's ecosystems—each becoming dependent on the other. However, European colonization upset the well established rhythm between humans and their environment. The temporal and spatial patterning of Indigenous fires was disrupted and low intensity burns occurred much less frequently or at different seasons. Fuels accumulated, and destructive crown fires frequently occurred that threatened settlers' homes and livelihoods (Pyne 1991). The process continues and is magnified today: extended drought, likely associated with global warming, has resulted in unprecedented wildfires (The Observer 2009). Increasingly, there is recognition that effective management of Australia's landscape must incorporate the long-term ecological knowledge held by Aboriginal peoples (BBC News 2007; Bird et al. 2005).

CASE STUDY 17.3 *Managing Extreme Environments: The Timbisha Shoshone of Death Valley, California*

The Timbisha Shoshone people live in one of most extreme environments in North America—the Mojave Desert. Sometimes referred to as Panamint, the Timbisha people were hunter-gatherers until non-Indian contact in the 1840s. They were seasonally transhumant, living on the floor of Death Valley in winter and in the surrounding mountains in summer. The twin hallmarks of their plant subsistence system were honey mesquite pods obtained in the valley and single-leaf pinyon nuts obtained in the mountains. Both were heavily harvested, stored for off-season use, and carefully managed. They also collected for food, seeds from many plant species, roots, greens, and berries. Game animals hunted included desert bighorn, occasional mule deer, hares and rabbits, woodrats, chuckwalla lizards, several small rodent species, and communal insects. In the 1850s, the Timbisha began cultivating corn, beans, squash, and devil's claw, obtained from the Southwestern tribes (e.g., Mohave, Tohono O'odham) to supplement their wild harvests. Today, most Timbisha homelands are within federally managed and restricted lands, including Death Valley National Park, the Mojave Desert Preserve and several military bases. All of these restrict traditional TREM activities, but elders still recall former practices (Fowler 1996).

In the past, the Timbisha Shoshone people practiced several aspects of TREM, including burning, pruning and coppicing, weeding and cleaning, and transplanting. All activities were approached with prayer, and deep respect was shown to all plants and animals harvested and tended. Taking care of the land and its resources was a deeply spiritual matter, and each individual respected the spirits of each place and item encountered. The pervasive ethic was stewardship and partnership among all living things. The Timbisha phrase “we live by them” implied that plants and animals provide for people and people are obligated to provide for them, as would neighbors. Plants and animals “hear” peoples’ prayers and talking as an acknowledgement of this interaction. They need to “feel” the presence of people in their everyday activities. Older people continually monitor the health of the land and its resources as they move about the landscape (Fowler 2000).

Prior to legal restriction, the Timbisha set controlled fires in a variety of ecosystems to encourage various plants and animals. In Death Valley, this was done to drive hares and rabbits, while also encouraging seeds such as white-stemmed blazing star. Burning in and around marshes controlled cattail and renewed grasses, and burning of stream banks controlled willows, promoted vigorous straight stems for basketry, and freed water for animals and people. The Timbisha also fired small patches of brush in openings in the pinyon forest to encourage tobacco, a favored medicinal and spiritual plant.

The Timbisha people pruned the lower limbs of mesquite and pinyon to open up groves for ease of harvesting, and for fuel wood. They pinched the growth tips of pinyon limbs to encourage branching for new cones, and beat the upper branches with long poles to remove dead cones and further prune for cone production. They cleared accumulated duff beneath mesquite and pinyon to aid in collecting beans and nuts, at the same time opening the under-storey to sunlight and moisture and encouraging seed germination and rooting. The people further aided grove regeneration by processing pods in the groves using stone mortars and wooden pestles. They pounded the pods to obtain the sweet, edible mesocarp, then discarded the hard “beans” or seed in the grove. Pounding scarified the seed, readying it for germination. People camping and walking throughout the groves in effect planted the seed.

Women coppiced willow to obtain straight growth the following season for basketry. They weeded and cleaned around desert prince's plume (a bush with edible leaves), removing only a few leaves for greens each spring. They cleaned springs and water-holding potholes in bedrock, and often “lidded” potholes with stones to discourage evaporation (while still allowing openings for animals to drink). They sometimes transplanted willows and other plants to different locations, but generally felt wild things were meant to stay in the environments in which they were created. They carefully monitored desert bighorn herds, never disturbing the lambing grounds.

The Timbisha have not been allowed to practice their traditional TREM since the 1930s, when Death Valley (now a U.S. National Park) and other areas came under strict federal control. In 2000,

the Timbisha Shoshone Tribe was granted land within the Park, with the right to co-manage certain other Park areas, especially mesquite groves and some pinyon forests. They have begun to reinstate their TREM on these lands (Fowler et al. 2003), and intend to return to the stewardship that has always been a part of their spirit if not their practice.



Figure 17.5 Stages of the “milpa cycle”: from the newly burned plot to maize canopy with squash and beans in four months, succeeding into a diverse open fruit and hardwood orchard in 5–7 years. Between 14 and 18 years later, this orchard culminates in a forest garden of useful trees and palms, which matures 20–30 years after the initial burn. Burned field photograph courtesy of BRASS/El Pilar Project; other photographs by Macduff Everton, used with permission). (See color insert.)

CASE STUDY 17.4

Managing the Forest: The Milpa Cycle of the Maya of the Yucatan Peninsula

The Maya are diverse peoples with long and complex histories. They are the inheritors of one of the most fascinating New World civilizations (Schele and Freidel 1990). Ancestral Maya worked out complex relationships with their tropical forest homelands, areas often characterized by poor soil and a fragile resource balance (Ford and Nigh 2009). Basically swidden farmers, both ancient and contemporary Maya practice forest management based on periodic burning and field and crop rotation. This system also incorporates animals, including game such as deer and peccary, and birds, bats, and insects that frequent the fields and recovering plots no longer in agricultural production. Among their most ecologically complex systems is their agroforestry, managed in conjunction with *milpa* fields and gardens. “Milpas are complex polycultural plots that are visually dominated by maize, but flourish with many other crops . . . including a bewildering variety of ‘weeds’ that serve as greens, herbs, medicine, pesticides and herbicides, as well as allelopathic plants . . .” (Ford and Emery 2008: 149; Fig. 17.5). The “high performance” milpa (Wilken 1987) mimics the surrounding forest in species composition and structure, and is the major component of the Maya subsistence system.

Research on the ethnecology and TREM of Maya milpa systems illustrates the complexity of these systems. For example, Nigh (2008) has shown that Lacandon knowledge of secondary forest regeneration after milpa cultivation and fallow closely matches, but is more detailed, than that of Western-trained forest ecologists. In addition, through a system of selective encouragement of specific new growth, and weeding and low intensity burning of weeds, the Maya are able to return a plot to useful forest, ready for a new milpa, in half the time predicted by forest ecologists (12–15 years as opposed to 25+ years). Once the old milpa is burned, the Maya purposefully encourage the growth of keystone species such as the balsa tree, with its profuse leaf litter. These trees keep out invasive species such as bracken fern and grasses that can overrun the field. Other fast-growing pioneers such as ramon and hog plum soon provide shade for other desired shade-tolerant plants. The Lacandon Maya also encourage species that will attract seed dispersers such as bats and birds as well as weeding recently fallowed areas, removing plants that will not contribute to new forest regeneration. Throughout the period of regeneration and the active life of the milpa, the Maya burn accumulated litter and incorporate it into the soil to create carbon (Nigh 2008: 239). These highly fertile soils are the mainstay of tropical forest agriculture in the Yucatan and elsewhere in tropical regions. Knowledge of forest succession and the application of these TREM activities allows soil fertility in cultivated areas to be maintained over the millennia.

Additional features of the milpa and agroforestry systems of the Yucatan Maya illustrate other aspects of TREM. For example, the Maya of Quintana Roo and elsewhere formerly kept wild bees, especially the stingless species, in hollow trees in their active and fallow fields. They collected wild swarms and introduced them to these new locations. The Maya have great respect for the bees and collected the honey for food, sale, and medicinal purposes. Their relationship with wild bees extends deep into the past and was well represented in the Maya religion (E. Anderson and Medina Tzuc 2005).

The Yucatec Maya routinely managed milpa margins and fallowed fields to increase game animals and birds. White-tailed deer, rabbits, and others were attracted by the new growth and were tamer and easier to hunt near these anthropogenic areas. This relationship between hunting and gardening likely extends well back into prehistory (Linares 1976; Emery and Thornton 2008).

REFERENCES

- ALCORN J. Huastec Maya Ethnobotany. Austin: University of Texas Press; 1984.
- AMES K, Maschner HDG. Peoples of the Northwest Coast: their archaeology and prehistory. London: Thames and Hudson; 1999.
- ANDERSON EN. Ecologies of the heart: emotion, belief, and the environment. New York: Oxford University Press; 1996.
- ANDERSON EN. Everyone eats: understanding food and culture. New York: New York University Press; 2005.

- ANDERSON MK. Tending the wild: Native American knowledge and the management of California's natural resources. Berkeley: University of California Press; 2005.
- ANDERSON EN, MEDINA TZUC F. Animals and the Maya of southeast Mexico. Tucson: University of Arizona Press; 2005.
- ATLEO ER. Preface. In: DUER D, TURNER NJ, editors. Keeping it living: traditions of plant use and civilization on the northwest coast of North America. Seattle: University of Washington Press; 2005. p vii–xi.
- BALÉE W. Footprints in the forest: Ka'apor ethnobotany—the historical ecology of plant utilization by an Amazonian people. New York: Columbia University Press; 1994.
- BALÉE W, ERICKSON C, editors. Time and complexity in historical ecology: studies from neotropical lowlands. New York: Columbia University Press; 2006.
- BARKHAM JP. The effects of coppicing and neglect in the performance of the perennial ground flora. In: PUCKLEY GP, editor. Ecology and management of coppice woodlands. London: Chapman & Hall; 1992. p 115–146.
- BBC NEWS. Aborigines burn the way to climate control. June 6 2007. Available at <http://news.bbc.co.uk/2/hi/asia-pacific/6726059.stm>.
- BECKWITH B. “The queen root of this clime”: ethnoecological investigations of blue camas (*Camassia leichtlinii* (Baker) Wats., *C. quamash* (Pursh) Greene; Liliaceae) and its landscapes on southern Vancouver Island, British Columbia [unpublished PhD dissertation]. Victoria (BC): Department of Biology, University of Victoria; 2004.
- BERKES F. Sacred ecology: traditional ecological knowledge and resource management. 2nd ed. Philadelphia (PA): Taylor and Francis; 2009.
- BERKES F, TURNER NJ. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Hum Ecol* 2006;34:479–494.
- BERMAN J. Red salmon and red cedar bark: another look at the nineteenth-century Kwakwaka'wakw winter ceremonial. Special issue: Ethnographic eyes. *BC Stud* 2000;125–126:53–98.
- BIRD DW, BIRD RB, PARKER CH. Aboriginal burning regimes and hunting strategies in Australia's western desert. *Hum Ecol* 2005;33:443–464.
- BOAS F. Kwakiutl ethnography (CODERE H, editor). Chicago: University of Chicago Press, 1966.
- CALDWELL, M.E. 2008. A View From the Shore: Interpreting Fish Trap Use in Comox Harbour Through Zooarchaeological Analysis of Fish Remains from the Q'umu'xs Village Site (DkSf-19), Comox Harbour, British Columbia. Unpublished MA thesis, Department of Anthropology, University of Manitoba. Winnipeg, MB.
- CRONON W, editor. Uncommon ground: toward reinventing nature. New York: W.W. Norton; 1995.
- CRUIKSHANK J. Do glaciers listen? Local knowledge, colonial encounters, and social imagination. Vancouver: UBC Press; 2005.
- CRUMLEY CL. Historical ecology: cultural knowledge and changing landscapes. Santa Fe: School of American Research Press; 1994.
- CRUMLEY C. From garden to globe: linking time and space with meaning and memory. In: MCINTOSH R, TAINTER JA, MCINTOSH SK, editors. The way the wind blows: climate, history, and human action. Series in Historical Ecology. New York: Columbia University Press; 2000. p 193–208.
- DENEVAN WM, editor. The Native population of the Americas in 1492. Madison: University of Wisconsin Press; 1992.
- DEUR DE. Salmon, sedentism, and cultivation: towards an environmental prehistory of the Northwest Coast. In: GOBLE D, HIRT P, editors. Northwest lands, Northwest peoples: an environmental history anthology. Seattle: University of Washington Press; 1999. p 129–155.
- DEUR DE. A domesticated landscape: Native American plant cultivation on the Northwest Coast [PhD dissertation]. Baton Rouge (LA): Department of Geography and Anthropology, Louisiana State University; 2000.
- DEUR DE. Tending the garden, making the soil: Northwest Coast estuarine gardens as engineered environments. In: DEUR DE, TURNER NJ, editors. Keeping it living: traditions of plant use and civilization on the Northwest Coast of North America. Seattle: University of Washington Press; 2005. p 296–330.
- DEUR DE, TURNER NJ, editors. Keeping it living: traditions of plant use and civilization on the Northwest Coast of North America. Seattle: University of Washington Press; 2005a.
- DEUR D, TURNER NJ. Introduction: reconstruction of indigenous resource management, reconstructing the history of an idea. In: DEUR DE, TURNER NJ, editors. Keeping it living: traditions of plant use and civilization on the Northwest Coast of North America. Seattle: University of Washington Press; 2005b. p 3–34.
- DIAMOND JM. Collapse: how societies choose to fail or succeed. New York: Viking; 2005.
- ELLEN RF, FUKUI K, editors. Beyond nature and culture: cognition, ecology and domestication. London: Berg; 1996.
- EMERY KF, THORNTON EK. Zooarchaeological habitat analysis of ancient Maya landscape changes. *J Ethnobiol* 2008; 28(2):154–178.
- FELGER R, MOSER MB. People of the desert and sea: ethnobotany of the Seri. Tucson: University of Arizona Press; 1985.
- FORD A, EMERY KF. Exploring the legacy of the Maya forest. *J Ethnobiol* 2008;28(2):147–153.
- FORD A, NIGH R. Origins of the Maya forest garden: Maya resource management. *J Ethnobiol* 2009;29(2): 213–236.
- FORD RI. Human disturbance and biodiversity: a case study from northern New Mexico. In: MINNIS PE, ELISENS WJ, editors. Biodiversity in Native North America. Norman: University of Oklahoma Press; 2000. p 207–222.
- FORD J, MARTINEZ D. Traditional ecological knowledge, ecosystem science, and environmental management. *Ecol Appl* 2000; 10:1249–1250.
- FOWLER CS. Historical perspectives on Timbisha Shoshone land management practices, Death Valley, California. In: REITZ EJ, NEWSOM L, SCUDDER S, editors. Case studies in environmental archaeology: essays in honor of Elizabeth Wing. New York: Plenum Press. (2nd ed. Reitz EJ,

- Scarry CM, Scudder SJ, editors. NY: Springer). 1996. p 87–101.
- FOWLER CS. “We live by them”: Native knowledge of biodiversity in the Great Basin of western North America. In: MINNIS PE, ELISENS WJ, editors. *Biodiversity in Native North America*. Norman: University of Oklahoma Press; 2000. p 99–132.
- FOWLER CS, WALTER NP. Harvesting Pandora moth larvae with the Owens Valley Paiute. *J Calif Great Basin Anthropol* 1984;7(2):155–165.
- FOWLER CS, ESTEVES P, GOAD G, HELMER B, WATTERSON K. Caring for the trees: restoring Timbisha Shoshone land management practices in Death Valley National Park. *Ecol Restor* 2003;21(4):302–306.
- GOTT B. Aboriginal fire management in southeastern Australia: aims and frequency. *J Biogeogr* 2005;32:1203–1208.
- GOTTESFELD LMJ. Conservation, territory, and traditional beliefs: an analysis of Gitksan and Wet’suwet’en subsistence, northwest British Columbia, Canada. *Hum Ecol* 1994;22:443–465.
- HALLAM SJ. *Fire and hearth*. Canberra: Australian Institute of Aboriginal Studies; 1975.
- HAMES R. The ecologically noble savage debate. *Annu Rev Anthropol* 2007;36:177–190.
- HARKIN ME, LEWIS DR, editors. *Native Americans and the environment: perspectives on the ecological Indian*. Lincoln: University of Nebraska Press; 2007.
- HARLAN J. *The living fields: our agricultural heritage*. Cambridge: Cambridge University Press; 1995.
- HEAD L. Landscapes socialized by fire: post-contact changes in Aboriginal fire use in northern Australia, and its implications for prehistory. *Archaeol Oceania* 1994;29:172–181.
- HEAD L. *Second nature*. Syracuse: Syracuse University Press; 2000.
- HODGSON WC. *Food plants of the Sonoran desert*. Tucson: University of Arizona Press; 2000.
- HUNN ES, with SELAM J and family. *Nch’i-Wána “the big river”: mid-Columbia Indians and their land*. Seattle: University of Washington Press; 1990.
- HUNN ES, JOHNSON DR, RUSSEL PN, THORNTON T. Huna Tlingit traditional knowledge, conservation, and the management of a “wilderness” park. *Curr Anthropol* 2003;44(Suppl):157–169.
- JOHANNES RE. *Words of the lagoon: fishing and marine lore in the Palau District of Micronesia*. Berkeley: University of California Press; 1981.
- JONES JPG, ANDRIAMAROVOLOLONA MM, HOCKLEY N. The importance of taboos and social norms to conservation in Madagascar. *Conserv Biol* 2008;22:976–986.
- JONES, R. Fire-stick Farming. *Australian Natural History* 1969;16:224–231.
- KARI J, FALL JA. *Shem Pete’s Alaska: the territory of the Upper Cook Inlet Dena’ina*. 2nd ed. Fairbanks: University of Alaska Press; 2003.
- KERSHAW AP, CLARK JS, GILL AM, C’COSTA DM. A history of fire in Australia. In: BRADSTOCK RA, WILLIAMS JE, GILL MA, editors. *Flammable Australia: the fire regimes and biodiversity of a continent*. Cambridge: Cambridge University Press; 2002. p 3–25.
- KIRCH PV, HUNT TL, editors. *Historical ecology in the Pacific Islands: prehistoric environment and landscape change*. New Haven (CT): Yale University Press; 1997.
- KOHNEN JL. Knowing country: Indigenous Australians and the land. In: SELIN H, editor. *Nature across cultures*. Boston (MA): Kluwer Academic Publishers; 2003. p 229–244.
- LANGDON SJ. Tidal pulse fishing: selective traditional Tlingit salmon fishing techniques on the West Coast of the Prince of Wales Archipelago. In: MENZIES CR, editor. *Traditional ecological knowledge and natural resource management*. Lincoln: University of Nebraska Press. 2006. p 21–46.
- LAWTON HW, WILKE PJ, DEDECKER M, MASON WM. Agriculture among the Paiute of Owens Valley. *J Calif Anthropol* 1976;3(1):13–50.
- LEPOFSKY D, KAHN J. Cultivating an ecological and social balance: Elite demands and commoner knowledge in ancient Ma’ohi agriculture, Society Islands. *American Anthropologist* 113(3):319–335.
- LEPOFSKY D. Gardens of Eden? An ethnohistoric reconstruction of Maohi (Tahitian) cultivation. *Ethnohistory* 1999;46:6–22.
- LEPOFSKY D, LERTZMAN K. Documenting ancient plant management in the northwest of North America. *Botany* 2008;86:129–145.
- LEPOFSKY D, HALLETT D, WASHBROOK K, MCHALSIE A, LERTZMAN K, MATHEWES R. Documenting precontact plant management on the Northwest Coast: an example of prescribed burning in the central and upper Fraser Valley, British Columbia. In: DEUR DE, TURNER NJ, editors. *Keeping it living: traditions of plant use and cultivation on the Northwest Coast*. Seattle: University of Washington Press; 2005. p 218–239.
- LERTZMAN K. The paradigm of management, management systems, and resource stewardship. *J Ethnobiol* 2009;29(2):339–358.
- LEWIS HT. *Patterns of Indian burning in California: ecology and ethnohistory*. Ramona (CA): Ballena Press; 1973.
- LEWIS HT. Technological complexity, ecological diversity, and fire regimes in Northern Australia: hunter-gatherer, cowboy, ranger. In: RAMBO A, GILLOGLY K, editors. *Profiles in cultural evolution*. Ann Arbor: Museum of Anthropology, University of Michigan; 1991. p 261–288.
- LEWIS HT. In retrospect. In: BLACKBURN TC, ANDERSON K, editors. *Before the wilderness: environmental management by Native Californians*. Menlo Park (CA): Ballena Press; 1993. p 389–400.
- LINARES OF. Garden hunting in the American tropics. *Hum Ecol* 1976;4(4):331–349.
- MACDOUGALL AS, BECKWITH BR, MASLOVAT C. Defining conservation strategies with historical perspectives: a case study from a degraded oak grassland ecosystem. *Conserv Biol* 2004;18:455–465.
- MARTIN GJ. *Ethnobotany: a methods manual*. London: Chapman and Hall; 1995.

- MENZIES CR, editor. *Traditional ecological knowledge and natural resource management*. Lincoln: University of Nebraska Press; 2006.
- MINNIS PE, PLOG SE. A study of the site specific distribution of *Agave parryi* in east central Arizona. *Kiva* 1976;41(3-4): 299-308.
- MOBLEY CM, MCCALLUM WM. Prehistoric intertidal fish traps from Central Southeast Alaska. *Can J Archaeol* 2001;25:28-52.
- MORAN EF. *Through Amazonian eyes: the human ecology of Amazonian populations*. Iowa City: University of Iowa Press; 1996.
- MOSS M, ERLANDSON J. A comparative chronology of Northwest Coast fishing features. In: BERNICK K, editor. *Hidden dimensions*. Vancouver: University of British Columbia Press; 1998. p 180-198.
- MOSS M, ERLANDSON J, STUCKENRATH R. Wood stake weirs and salmon fishing on the Northwest Coast: evidence from southern Alaska. *Can J Archaeol* 1990;14:143-158.
- NABHAN GP. *Cultures of habitat: on nature, culture and story*. Washington (DC): Counterpoint Press; 1997.
- NABHAN GP. Cultural dispersal of plants and reptiles to the Midriff Islands of the Sea of Cortés: integrating indigenous human dispersal agents into island biogeography. *J Southwest* 2000;43(3):545-558.
- NADASDY P. The politics of TEK: power and integration of knowledge. *Arctic Anthropol* 1999;36:1-18.
- NIGH R. Trees, fire and farmers: making woods and soil in the Maya forest. *J Ethnobiol* 2008;28(2):23.
- NORTON HH, BOYD R, HUNN ES. The Klickitat trail of south-central Washington: a reconstruction of seasonally used resource sites. In: BOYD R, editor. *Indians, fire and the land in the Pacific Northwest*. Corvallis: Oregon State University Press; 1999. p 65-93.
- PEACOCK SL, TURNER NJ. "Just like a garden": traditional resource management and biodiversity conservation on the interior plateau of British Columbia. In: MINNIS PE, ELISENS WJ, editors. *Biodiversity in Native North America*. Norman: University of Oklahoma Press; 2000. p 133-179.
- PYNE SJ. *Burning bush. A fire history of Australia*. New York: Henry Hold; 1991.
- ROBBINS WW, HARRINGTON JP, FREIRE-MARRECO B. *Ethnobotany of the Tewa Indians*. Bulletin 55. Washington, DC: Bureau of American Ethnology; 1916.
- ROSEN AM. The social response to environmental change in early Bronze Age Canaan. *J Anthropol Archaeol* 1995;14:26-44.
- SCHELE L, FREIDEL D. *A forest of kings*. New York: William Morrow; 1990.
- SHACKLETON CM. Fuelwood harvesting and sustainable utilization in a communal grazing land and protected area of the eastern Transvaal Lowveld. *Biol Conserv* 1993;63: 247-258.
- SUTTLES WP. Affinal ties, subsistence, and prestige among the Coast Salish. In: SUTTLES WP. *Coast Salish Essays*. Vancouver: Talonbooks; 1987. p 15-25.
- THE OBSERVER. 8 February. Dozens die as Australia's wildfires rage; 2009. Available at <http://www.guardian.co.uk/world/2009/feb/07/bush-fires-australi>.
- TRUSLER S, JOHNSON LM. "Berry patch" as a kind of place—the ethnecology of black huckleberry in Northwestern Canada. *Hum Ecol* 2008;36:553-568.
- TURNER NJ. "Time to burn": traditional use of fire to enhance resource production by Aboriginal peoples in British Columbia. In: BOYD R, editor. *Indians, fire and the land in the Pacific Northwest*. Corvallis: Oregon State University Press; 1999. p 185-218.
- TURNER NJ. *The Earth's blanket. Traditional teachings for sustainable living*. Vancouver and Seattle: Douglas & McIntyre, and University of Washington Press; 2005.
- TURNER NJ, PEACOCK S. Solving the perennial paradox: ethnobotanical evidence for plant resource management on the Northwest Coast. In: DEUR DE, TURNER NJ, editors. *Keeping it living: traditions of plant use and civilization on the Northwest Coast of North America*. Seattle: University of Washington Press; 2005. p 101-150.
- TURNER NJ, IGNACE M, IGNACE R. Traditional ecological knowledge and wisdom of Aboriginal peoples in British Columbia. *Ecol Appl* 2000;10(5):1275-1287.
- TURNER NJ, SMITH R, JONES JT. "A fine line between two nations": ownership patterns in plant resources among Northwest Coast Indigenous peoples. In: DEUR DE, TURNER NJ, editors. *Keeping it living: traditions of plant use and civilization on the Northwest Coast of North America*. Seattle: University of Washington Press; 2005. p 151-178.
- WADDELL E. *The mound builders: agricultural practices, environment, and society in the Central Highlands of New Guinea*. Seattle: University of Washington Press; 1972.
- WEISER A, LEPOFSKY D. Ancient land use and management of Ebey's Prairie, Whidbey Island, Washington. *J Ethnobiol* 2009;29(2):184-212.
- WHITE E. *Heiltsuk stone fish traps: products of my ancestors' labour* [MA thesis]. Burnaby (BC): Department of Archaeology, Simon Fraser University; 2006.
- WHITING AP. *Ethnobotany of the Hopi*. Bulletin 15. Flagstaff: Museum of Northern Arizona; 1934.
- WILKEN GC. *Good farmers: traditional agricultural resource management in Mexico and Central America*. Berkeley: University of California Press; 1987.
- WILLIAMS J. *Clam gardens: Aboriginal mariculture on Canada's West Coast*. Vancouver (BC): New Star Books; 2006.
- WOODS DJ, WOODS D, producers. *Ancient sea gardens. Mystery of the Pacific Northwest—film*. Toronto (ON): Aquaculture Pictures; 2005.
- ZEDER M, BRADLEY DG, EMSHWILLER E, SMITH BD, editors. *Documenting domestication*. Berkeley: University of California Press; 2005.

Chapter 18

Ethnobiology and Agroecology

E. N. ANDERSON

Department of Anthropology, University of California, Riverside, CA

DEFINITIONS	305
ORIGINS	307
AGRICULTURAL SYSTEMS	309
AGRICULTURE AND RITUAL	310
REHABILITATING SWIDDEN FARMING	310
HOMEGARDENS	311
MODERN APPLICATIONS: BIODIVERSITY	311
METHODS	312
CONCLUSION	315
REFERENCES	315

DEFINITIONS

The field of agricultural ethnobiology is far too large to review in a chapter, and many chapters in this book cover aspects of agriculture in some way (see also Harlan 1992, 1995). Every issue of *Economic Botany*, *Ethnobotany Research and Applications*, and *Journal of Ethnobiology* adds several new titles, and important articles appear in *American Anthropologist*, *Antiquity*, *Current Anthropology*, and several biology journals, as well as the *Culture and Agriculture* journal of the American Anthropological Association's Culture and Agriculture section. This chapter is thus confined to particular ethnobiological problems of definition, application, and method.

Standard definitions of "agriculture" involve the deliberate planting, tending, and harvesting of plants and animals that are truly domesticated, that is, modified by selective breeding until they show marked differences from any wild stocks. Many ethnobiological studies focus on peoples who fall between "hunter-gatherer" and "agricultural" societies, and on practices that are neither classic "hunting-gathering" nor "farming" (cf. Harlan 1992, 1995). People who have few or no domesticated crops often practice intensive plant

management of wild stocks (see chapters in this volume by Fowler and Lepofsky and by Turner). Controlled burning is by far the most important method, but pruning, cultivating, transplanting, and even local irrigating and seed-sowing are or were commonly practiced.

Kat Anderson's research on Native Californian peoples (M.K. Anderson 2005; Blackburn and Anderson 1993) disclosed massive vegetation management that affected millions of acres of the California landscape. Nancy Turner has done the same for the Pacific Northwest, producing a "five foot shelf" of books (for reviews and citations see Deur and Turner 2005; Turner 2005; Turner and Nolan, 2011). Eugene Hunn has studied similar intensive management of wild plants among the Sahaptin peoples of Washington (Hunn 1990). Richard Felger and collaborators have recorded wild plant management among the Seri of northwest Mexico (Felger and Moser 1985). In some cases, true domestication emerged locally in such groups. The wild bulb known as camas (*Camassia quamash* and *C. leichtlinii*) seems semi-domesticated. Over all this vast area, however, only one crop was more or less domesticated or at least widely sown and tended in prepared fields: tobacco (Winter 2000). Evidently, people felt more need to expend special effort on a medicinal and ceremonial plant than on food! For these cultures, however, it was a ritual, not an indulgent, drug.

Comparable dynamics are well known throughout much of South America, Australia, and other areas worldwide. Only a few "hunter-gatherers" are true foragers in the old sense, simple croppers of nature's bounty (Williams and Hunn 1982).

Florence Shipek's studies of the Kumeyaay and related groups in southern California and northern Baja California showed that the same groups and even the same individuals were often "agricultural" when staying at desert oases but "hunter-gatherers" on the coast. Not surprisingly, the coastal groups cultivated, transplanted, and probably even sowed seeds (Cuero 1970; Shipek 1989). The nearby Uto-Aztecanspeaking Cahuilla (Bean and Saubel 1972), Tohono O'odham (Nabhan 1987, 1997), Serrano, and Southern Paiute (Laird 1976) were divided into agricultural and non-agricultural groups, with membership being fluid. The Owens Valley Paiute not only cultivated wild plants, but constructed extensive irrigation works to do so (Lawton et al. 1976). All this is less surprising now that we know that the Uto-Aztecanspeaking peoples have been agricultural since their early dispersal from Mexico (Hill 2001); non-agricultural groups appear to have recently stopped farming because of entry into areas where it was less optimal than foraging. Similar situations in Paraguay (Reed 1995) and Bolivia (Stearman 1984) are well known; anthropologists seeing Paraguay hunters as pristine examples of humanity in its pre-agricultural state have sometimes been embarrassed by discovering that the people in question once had highly advanced agriculture. Some groups in dry southern Madagascar are agricultural in wet years, hunter-gatherers in dry (Stiles 1991). Alternation between nomadic stock-herding and settled farming is famously common in central Asia (e.g., Barfield 1989).

Many groups farm, sometimes quite intensively, but depend largely on wild foods for calories and nutrients. Several Southwest peoples are in this category: the desert Cahuilla, Mohave, Yuma, and neighboring peoples. Some Northern Plains cultures, including the Mandan and Hidatsa, seem to have been in this category. There are similar groups all over the world.

Tim Ingold (2000) has radically critiqued the whole idea of "agriculture." Clearly, we must see agriculture as a set of activities that lie on a broad continuum. At one extreme is minimal management of the landscape, found among Inuit and other very thinly populated groups. At the other is full-scale industrial farming. In between lie peoples having every conceivable mix of techniques.

In fact, no purely "agricultural" people is known. Modern Americans pick wild blackberries, fish for salmon or sunfish, chop firewood in the forest, and hunt deer. Europeans

gather wild plants (Svanberg et al., 2011). In modern societies such pursuits usually contribute few calories to the diet, but hunting is still a basic subsistence activity in many rural areas of North America and Europe.

Even greater difficulties exist with the differentiation of “agriculture” from “horticulture,” well established in ecological anthropology (Steward 1955) and enshrined in textbooks (e.g., Kottak 2008). Usually, agriculture is seen as involving the plow, and thus being “more intensive,” “more productive,” and having a greater effect on life in general. Horticulture then becomes a residual category involving farming by hoe, digging stick, or other small hand tools. Sometimes an evolutionary sequence from horticulture to agriculture is stated or (as in Kottak) implied.

Yet, among the first successes of the ethnobiological approach were demonstrations of the fantastic level of knowledge, skill, and technique among “horticultural” peoples, for example in the classic work *Hanunoo Agriculture* by Harold Conklin (1957; see related work, Klee 1980; Marten 1986; Spencer 1966). “Horticulture” has supported great civilizations, including all the New World ones (Maya, Aztec, Inca, etc.). The existing “horticultural” systems of the Maya of Mexico are among the most complex, skill-intensive, and productive systems of traditional agriculture ever described (E. Anderson 2005b). Some intensive wet-rice farmers plow; some do not, yet the difference is not great.

Conversely, exceedingly simple, low-production plow agriculture was the rule in much of Europe a century or two ago. A wonderful account, far from scholarly ethnobiology but accurate and graphic, is Aleksis Kivi’s great novel of Finnish frontier life in the nineteenth century, *Seven Brothers* (1991). Many peoples do some plowing but not much, and others plow under some circumstances but not in others.

Thus, most ethnobiologists (though not all) confine the word “horticulture” to its original meaning, that is, cultivation of small gardens (Latin *hortus* “garden”) near the home as opposed to larger and more distant fields (Latin *ager* “field”), and use “agriculture” to cover all field systems. (Many societies make the same distinction as the Latin: e.g., Yucatec Maya *wolk’ot* “walled garden” and *kool* “field.”)

The above findings drive the last nail into the coffin of simple unilineal evolutionism. In the nineteenth century, it was thought that “savages” lived by hunting and gathering, then either “discovered” that plants could be grown from seed or “evolved” through animal keeping (pastoralism, “barbarism”; Morgan 1877), and became horticultural; then horticulture “evolved” into agriculture. Obviously, this neat scenario does not hold up. We must assume, as the great geographer Carl Sauer (1952) pointed out, that the inventors of agriculture already knew a great deal about plant management and reproduction. We must also see contemporary hunter-gatherer peoples as the end products of evolutionary or historic sequences as long, complex, and interesting as those leading to modern civilizations. Archaeology reveals, for instance, that many of the highly sophisticated practices of wild plant cultivation by hunter-gatherers have fascinating developmental prehistories (Fowler and Lepofsky, 2011). Usually, agriculture supports far larger populations, but not necessarily so; the population density of “hunting-gathering” or complex-forager societies on the Pacific Coast of North America, northern Australia, and Mesolithic Europe were greater than that of many agricultural societies.

ORIGINS

Agriculture began independently in several areas: the Near East around 11,500 BP, China perhaps as early (firm evidence by 10,000 BP), Mexico by roughly 7000 BP (the date remains highly controversial), Peru and lowland South America at least as early (and very

likely involving at least two separate inventions; Piperno and Pearsall 1998), and New Guinea perhaps 6000 BP or earlier (Golson 2007 [1989]). Early agriculture in west Africa, India, Japan, and interior eastern North America may have involved independent invention. Agriculture requires “domestication”: selection (deliberate or inadvertent) by people, such that the domesticated plant or animal is genetically different from anything found in the wild. Much of the general literature is written by archaeologists, but the data discussed here is from archaeoethnobiologists, many of whom are cited below.

After doing well for countless millennia without farming, people all over the world almost simultaneously began a long, complex change. Many theories explaining this have been proposed. Graeme Barker’s recent review (2006) is particularly good, and particularly merciless to simplistic theories. (See also Cohen 2009; Denham and White 2007; Denham et al. 2007; Marcus and Stanish 2006; Zeder 2008; Zeder and Hesse 2000; Zeder et al. 2007.) Richard S. MacNeish (1991) summarized conditions shared by the five or six earliest areas: warm tropical or subtropical habitat, with strongly marked seasonality (cool–warm or wet–dry), and with complex interfolding of ecological zones. Such areas have the maximum variety of plant species within a limited area. They make trade between local groups not only likely but virtually necessary, to make good use of all the ecological zones. They also have a maximum number of plants that produce storage structures like starchy seeds, tubers, and roots; this is because the plants can thus make maximal growth during warm, moist conditions and store food for the cold or dry seasons. Humans do likewise, harvesting nature’s bounty at the end of the favorable season and storing the starchy structures.

The end of the Pleistocene, 12,000 years ago, was followed by a rapid and dramatic warming suddenly halted by an even more dramatic reversal (the “Younger Dryas Period”) around 10,500–11,500 BP. These sudden swings led to rapid expansion of plant life in the zones in question, then rapid contraction again, then rapid expansion again. Agriculture may have begun just before the Younger Dryas, stimulated by the sudden rebirth of plant life; this is suggested by possibly agricultural rye grains at Abu Hureyra (Balter 2010). Or agriculture may have appeared during the Younger Dryas, as a way of keeping the staple foods around the home when people were forced to settle around limited oases (this recoups Gordon Childe’s old theory; Childe 1954). Or it may have come about after the Younger Dryas, again with expanding plant life (Zeder 2008). In the other origination areas, agriculture came later, with no obvious climatic correlates, and indeed no obvious correlates at all: no population increase, no local extinctions of wild foods, no special evolutionary pressures on local plants.

East Asia domesticated rice and millets early. Mesoamerica gave us maize, beans, and squash. South America domesticated other species of beans and squash as well as quinoa and other crops. Africa domesticated other types of millets, which spread early to India and had major influence there (Weber 1998; Weber and Belcher 2003), proving the profound influence of Africa on neighboring cultural areas.

Domestic animals, except for the dog, came later. The dog was probably domesticated by 12,000 BC or earlier in the Near East; dog domestication was apparently a matter of pet keeping in hunting societies. Many fewer species of animals than of plants were domesticated. Only the Near East, China (probably), and Peru actually domesticated animal species. The first domesticate in the Near East (after the dog) was probably the goat, and, perhaps a bit later, sheep, around 7500 BC (Zeder 2008). South American peoples domesticated the llama around 6000 BP, and subsequently the guinea pig, alpaca, and, in the lowlands, the Muscovy duck.

Archaeoethnobiological research shows that agriculture was extremely slow to pay well. Thousands of years elapsed before simple primitive domesticates were bred into varieties

hardy and high yielding enough to be major foods. As Carl Sauer pointed out long ago, this shows that agriculture did not arise from a simple need for more food (Sauer 1952). Sauer also emphasized that all peoples realized that seeds gave rise to plants. This was no late discovery that somehow unlocked the secret of agriculture (an idea that, incredibly, is not extinct). Trade, preference, security, transplantation to better growing areas, and non-food uses like fiber (Sauer 1952), containers (Lathrap 1977), and drugs (notably tobacco; cf. Winter 2000) were evidently involved.

Rarely noted is the importance of microorganisms in the rise of agriculture (E. Anderson 2005a). Yeasts for wines, beers, and baking; *Lactobacillus* in yogurt and fermented foods; fungi in soy sauce; and many other microorganisms were necessary adjuncts to the rise of fully agricultural societies, because they produce nutrients of their own (notably vitamin B12), release nutrients in plant foods, and break down toxins in some plants (such as soybeans). Our familiar wheat bread rises because of yeasts, ultimately from winemaking. The natural habitat of the usual baking and brewing yeast *Saccharomyces cerevisiae* is the grape.

Another reason that bread rises so well is that a strain of the wild grass *Aegilops squarrosus* growing just southwest of the Caspian Sea was bred into wheat around 8000 years ago (E. Anderson 2005a). This strain of grass included a strong gluten that, after kneading in a moist dough, traps air bubbles and allows bread to puff up to twice or more the size of the dough mass. Developing this—evidently by women, and of course working under Neolithic conditions—took sheer technical genius.

Agriculture, at least sometimes, was spread by particular groups of people, and thus spread locally along with languages. This is best documented for the Austronesian language phylum, and is increasingly controversial for other phyla (see Bellwood and Renfrew 2002, which includes critiques as well as advocacy; a recent summary in Bellwood 2009; Heggarty and Beresford-Jones 2010). Claims have run far beyond likelihood; the Indo-European language family almost certainly spread long after agriculture came to Europe (Anthony 2007).

As agriculture intensified, it almost always had the unfortunate effect of causing a deterioration in health. This was because population grew more dense, and people became more dependent on starch staples. These are typically short in protein, vitamins (especially B12, C, and folic acid) and minerals (especially iron). Also, complex intensive agriculture typically accompanied more differentiated societies, in which elites monopolized the best foods and left the commoners little beyond bulk starch. A pattern of overnutrition for the few and undernutrition for the rest emerged early in the Chinese archaeological record, for example (Chang 1977). Agriculture has thus recently been condemned as humanity's worst invention (Manning 2005), but it permitted high civilization, cities, great literature, and other benefits.

AGRICULTURAL SYSTEMS

Ethnobiologists and ethnoecologists have focused on studying traditional management systems in small-scale and local societies. The enormous knowledge that traditional cultures encode, and the enormous care with which farmers deploy it in managing resources, have both been the foci of research. Ethnographies and reviews stress this point (see, e.g., Hunn 2008; Klee 1980; Marten 1986; Nazarea 1999; Turner and Brush 1987; Wilken 1987). The largest single literature concerns Latin America, especially southern Mexico, where the huge Harvard–Stanford–Chicago project studied Chiapas in the 1950s (Vogt 1994). A large percentage of today's leading ethnobiologists began their careers in Chiapas, directly or indirectly because of this project.

Farmers may crop wild plants, plant fruit trees in the forest, selectively leave useful species when they clear fields, deliberately manage regrowth, and otherwise integrate tame and wild (Anderson 1952, 2003; Balee 1994; Conklin 1957; Posey 2004). “Weeds” may be important to the system (Anderson 1952), as famine foods, supplemental resources, potential crops, or animal food. The Yucatec Maya protect the cycad *Zamia lodigesii* because its roots provide the most effective rat poison locally available, and grow *Martynia annua* solely because its sticky leaves trap fleas (Anderson 2003).

Domestication is a relative matter. At one extreme are starch staples—plants such as maize, so totally domesticated that it does not exist in the wild and cannot survive there, and which occurs in many carefully managed varieties. At the other are all manner of wild plants cultivated or tolerated in gardens. In between fall plants that are domesticated but less dependent on cultivation, then those that are only slightly modified from the wild form (Stuart 1978). Plants propagated by seed can be selected faster and more rigorously than plants vegetatively propagated (by cutting or grafting). Some species have gone in and out of cultivation, sometimes because of the decline of Indigenous populations or lifestyles (Clement 1999 provides a discussion of this and a table of degrees of domestication). Edgar Anderson (1952) saw “dump-heaps” and weedy areas as the home of cultivated crops. This seems to be only sometimes true, but certainly the plants with a “weedy habit”—a fondness for growing in human-disturbed places—are good candidates.

AGRICULTURE AND RITUAL

Cultural ecologists and ethnobiologists have drawn attention to the importance of agricultural ritual and religion (Rappaport 1984). So far as is known, *all* traditional agricultural peoples represent agriculture religiously, usually through ceremonies: blessings of the farm tools, rain prayers, church suppers to share produce, magic to protect crops, harvest celebrations, offerings to the spirits of the field and forest, calendric rites that coordinate farm work with solstices or equinoxes, or the like. To the outside observer, the benefit of this seems largely social: it brings people together, involves the community in the enterprise, synchronizes work, and enforces rules against planting at the wrong time or stealing others’ crops. Traditional societies often code resource management, including conservation, as religious prescription or proscription (Rappaport 1984). This is true in hunting-gathering as in agricultural societies (Berkes 1999). Ritual use may preserve ancient crops that would otherwise be abandoned (Dove 1999).

Sometimes an entire agricultural system is coordinated religiously—perhaps most often in the case of irrigation (e.g., Gelles 2000; Lansing 1991, 2006; cf. Remmers 1998), but also very notably in the case of conservation (E.N. Anderson 1996, 2005b; Huber 1999). Often, ceremonies involve the heavy use of plants and animals, and whole ethnobiological studies have been devoted to them. The extreme importance of religious ideology in organizing agricultural enterprise was studied by John Bennett (1982).

REHABILITATING SWIDDEN FARMING

A major contribution of systems research within ethnobiology has been the rehabilitation of swidden farming (also known as slash-and-burn, or *roza-tumba-quema*, Spanish for “slash-fell-burn”). Widely condemned for destroying forests and leaving wasteland, swidden agriculture has turned out to be a highly adapted form, which not only preserves forests

but increases the percentage of species useful to humans (Balée 1994; Spencer 1966; Wilken 1987).

Many local forms of swiddening exist, differing in management details. Southeast Asia in general is home to amazingly sophisticated and intricate swidden systems, which often involve tree cropping, home gardens, small permanent fields, forest gardens, and several other forms of cultivation as well as swidden fields (Conklin 1957, 1981, 2007; Klee 1980; Spencer 1966; Ayoë Wang, research in progress). Similarly, famous work in South America was done by Darrell Posey (2004) on the Kayapo. Among the most specialized and complex, and also among the best studied, is the milpa agriculture of tropical Mexico (E.N. Anderson 2005b; Atran 1999; Fedick 1996; Ford and Emery 2008; Gomez-Pompa 1987; Gomez-Pompa et al. 2003; Stuart 1978; Terán and Rasmussen 1993; Terán et al. 1998).

The teak forests of southeast Asia and the fruit tree-rich forests of tropical America are products of forest management by swidden farmers. Swiddening destroys forests only when done carelessly, often in pioneer environments, or when population density builds up rapidly. The latter situation is common in modern situations in which swiddeners are not allowed to move or are deprived of much of their traditional land base.

HOMEGARDENS

Considerable ethnobiological research has concerned homegardens, because they tend to preserve much diversity, especially of minor plants and animals, including medicinals, ornamentals, and other special-purpose items. Their role in domesticating plants was emphasized in Edgar Anderson's classic *Plants, Man and Life* (1952). Homegardens are vital to many of the world's peoples, providing essential nutrients and cash income as well as household amenities. Homegardens often include more than 100 species of cultivated plants, and several animal species. The most diverse seem to occur in tropical America (including the Maya area; Anderson 2003; Ford and Emery 2008; Hunn 2008), where close to 200 species may be found in one garden. Southeast Asia is also notably rich (Anderson 1993b). Conversely, some areas, including Madagascar (E. Anderson, unpublished research), are far less concerned with dooryard gardening.

Special attention has been paid to dryland gardens in an extremely valuable how-to manual by a pair of ethnoecologists, David Cleveland and Daniela Soleri (1991). Further work on worldwide variations in gardening is needed. (Anderson 1993a provides a fairly complete review of the literature up to that date, but since then the literature has exploded; see Agelet et al. 2000; Eyzaguirre and Linares 2004; Hunn 2008; also Anderson, 2009).

MODERN APPLICATIONS: BIODIVERSITY

Ethnobiologists have documented an enormous variety of cultivated plants, and have raised major concerns over the disappearance of cultivars and landraces (Benz et al. 2007; Brookfield et al. 2002). The number of these is truly incredible; the International Rice Research Institute has hundreds of thousands of varieties of rice in their seed banks, and the worldwide number of local races of wheat, barley, maize, and millets cannot be far behind. Some villages in the Andes grow hundreds of varieties of potatoes. The diversity of beans, chilies, and other crops is also enormous. Some 7000 varieties of apples were known a century ago (Ripe 1994), but now only a few dozen are in commercial production.

Minor cultivated species include obscure local edible vegetables such as the Central American loroco (*Fernaldia pandurata*), interesting because it is in the family Apocynaceae, many of whose members are toxic to humans. Recent ethnobiological investigation of little-studied spices and flavorings includes recent work on vanilla (Lubinsky et al. 2008). Minor drug and medicinal plants, ornamentals, and other useful plants expand the list of cultivated species well into five figures.

Endangered animal cultivars include not only traditional local races of sheep, cattle, dogs, cats, water buffaloes, camels, llamas, and other species, but also modern animals with odd uses, such as specially bred experimental strains of flies, mice, and rats. Fungi, always little studied, receive what little attention they get largely from ethnobiologists and economic botanists (Arora and Shepard 2008; Yamin-Pasternak 2011).

Local people typically save these landraces, and grow a wide variety in their farms, suiting particular varieties to particular pasture or soil or other environmental conditions. It is normal simply to grow a wide variety for insurance (some drought-resistant strains and some water-resistant ones, for instance) or simply for pleasure (see, e.g., Anderson 2003; Lacy et al. 2006). Traditional farmers are aware of the dangers of seed saving and maintaining seed lines, and have to deal with these (see, e.g., McGuire 2007).

Ethnobiologists have often been in the forefront of documenting and saving these strains. Companies like Native Seed Search, founded by ethnobiologists including Gary Nabhan, specialize in heirloom seeds. Hugh Popenoe developed the first significant herd of water buffaloes in the United States (Bost 2009). At least equally important is work with local farmers to save rare domesticates *in situ* (for many of these questions, see Brookfield et al. 2002; Pocock 1992).

Many a minor crop has become major because of work by economic botanists and ethnobiologists; the extreme case is the soybean, whose leap from local East Asian specialty to world dominance was due to a great extent to the efforts of one man, Charles Piper (1923). Many more minors are waiting in the wings, ready to become majors. The winged bean (*Psophocarpus tetragonolobus*), for instance, could be the soybean of the future (National Academy of Sciences 1975). The National Academy of Sciences (1989, 1996, 2006) has published several books on local traditional crops with major global potential.

METHODS

Most small farmers, whether in California or the Upper Amazon, survive by knowing an incredible amount about their work; information and skill substitute for capital. Getting at that knowledge requires diverse techniques (see other chapters of this volume, as well as Bernard 2006; Frake 1980; Martin 2004).

As in field social science in general, the basic technique is participant observation. Among several guides to this activity, *Participant Observation: A Guide for Fieldworkers* has the advantage of being written by Kathleen and Billie DeWalt (2001), agrarian anthropologists with an unexcelled background in the ethnography and ethnoecology of traditional small-scale farming systems.

Long, probing interviews are often necessary, and require special preparation; see McCracken, *The Long Interview* (1988). Detailed histories of local agriculture, or even of one garden or plot of ground, are extremely valuable.

Collecting vouchers of crop plants is obviously required. Vouchers of each local variety, and indeed of every visible variant of each variety, are necessary for specialized studies.

Visual documentation through photographs is essential, and garden and field maps, videotapes, and other such media are widely used to valuable effect. Tape recording of interviews is generally essential; recording field sounds can be important.

Freelisting—simply asking the consultant to name every plant, or every garden plant—rarely gets one far, at least in the tropics, because the list is so huge that no one can recall much of it at one shot. Asking for a freelist of fruits, one of greens, one of animals, and so on is usually necessary if one is to use the freelist technique, but many investigators prefer to go around with consultants to gardens and fields and simply get the list from out-right observation supplemented by asking “What other kinds of X are grown here?”

Taxonomies—whether scientific or folk—can be truly complex, because varieties of a single species may blend into each other, and cross at any time in the field. Plants may “sport”: undergo tissue (rather than germplasm) mutations that can make one branch of a plant different from other branches. Varieties are also particularly prone to be named differently in neighboring villages. Often, a variety will be locally known by the name of the person who first grew it in that village.

Reasonably obvious is the need to collect statistics. Many an anthropologist has gone into the field with little guidance beyond the classic line “count everything countable,” and indeed it is probably the most basic advice (after “wear stout hiking boots”). Countable things include data on yields per acre, yield per seed or tuber sown, yield of fruit per tree, average size of fruit, number of species sown in a field, and so on. Local government offices usually collect statistics on overall yields and sown acreage, but not always accurately, and they almost never collect data on small patches of land or on homegardens.

Researchers must be alert to minor benefits of local small fields and gardens. The Yucatec Maya not only get maize from their *milpa* fields; they grow minor crops, gather wild edible and medicinal plants (often carefully protected during weeding), hunt game attracted by the growing crops, nibble wild fruit while walking to and from the milpas, collect firewood, observe the weather and the forest to assess future work, assess wildlife populations, cut small firebreaks around individual valuable trees, and so on (E. Anderson 2005b; Faust 1998; Terán and Rasmussen 1993). Much of the vitamin nutrition in many rural areas comes from nibbling on the way to and from fields. Without actually accompanying farmers at work, researchers miss most of the above, and get a wholly wrong idea of the “simplicity” of small-scale agriculture.

Creating and cultivating an entire field of one’s own, as did Alicia Re Cruz (1996), is perhaps too much for less heroic participant observers, but there is *no* substitute for accompanying (and often helping) farmers in their fields. Thousands of hours of literal “field” work are required. Working in the kitchen on food storage, food preparation, and food preservation is necessary, since these processes are hard to explain in words and are *far* less well documented, in spite of their extreme importance in archaeological, ethnobiological, agronomic, and economic research (Huang 2000; McCune and Kuhnlein, 2011; Wandsnider 1997), even though ethnobiologists have always stressed the fact that food production and consumption make up one system (E. Anderson 2005a; Cushing 1920).

A valuable technique for ethnoagronomic research is decision-tree modeling. This was brought to this field from formal economics by Christina Gladwin (1977, 1989), who used it to study small-scale maize farming in Mexico. She found that resistance to the Plan Puebla, a government plan to develop maize, was due not to peasant conservatism but to very specific problems with the plan itself. Gladwin’s excellent guide to decision-tree analysis (1989) should be in every fieldworker’s luggage; it includes a summary of Rapid Rural Assessment (RRA), a technique that allows important findings to be made without the need for a full year in the field.

Work has continued in agriculture (Barlett 1980, 1982), including homegardens (Finerman and Sackett 2003), and ethnobiologists and ethnoecologists have expanded it to medical ethnobotany (Quinlan 2004), food preparation, and other fields. A particularly sensitive, thorough, and insightful study of what can and cannot be done with decision-tree modeling is found in Kimberly Hedrick's study of ranching (Hedrick 2007).

Basically, this technique involves building a more or less formal model or flowchart of a process. One first finds out the sequence of things that have to be done: select seed, put seed in bag, plant, weed, and so on. One then finds out what choices are possible at every point: select red seeds versus white ones, put seed in bag or open bin, plant in holes or rows, and so on. Ideally, all these should be dichotomous choices, that is, with only two alternatives; formal modeling breaks choice-points with multiple possibilities into several choices. This may get unrealistic if, say, the farmer is separating red, white, blue, and striped maize seeds (Stuart 1978), but usually it is close to psychological truth. One can then construct a standard flowchart of the whole process.

Finding out what decisions actually come first and what are second, third, and so on, turns out to be more fascinating and revealing than many would suspect. In an unpublished study of backyard vegetable growing, my students and I found out that the first thing considered was the sweetness of the result; gardeners started by hoping they could grow sweet corn and other sweet vegetables, then figured out what steps they had to go through to do that. Supermarket vegetables just didn't have the flavor. Randall (1977) and Anderson and Anderson (1978) found that fishermen in Southeast Asia were less concerned with fish and fishing *per se* than with making a living.

Formal decision-tree modeling is not really necessary if one goes through the effort of finding out through both interviewing and legwork the actual steps in the farming or food preparation process. In general, farmers plan meticulously and know the steps of any given process perfectly well, but do not think in formal flowchart terms (unless they have agricultural economics degrees, as many now do). Researchers may find it more psychologically real to describe the process in steps but not in formal tree structures. Formal models are valuable heuristics for the researcher and can be very good ways to show steps concisely, but do not necessarily make for accurate analysis, partly because a farmer may be taking a truly enormous number of factors into account, often through rapid and even subconscious assessment. A practiced farmer, for instance, does not need to go through a detailed procedure to figure out whether the soil is moist enough to plant; he or she "knows it by feel" from long experience, and will probably find it hard to describe in formal terms.

An ideal ethno-agricultural study should allow the reader to farm, harvest, and store and prepare food as do the people described (Frake 1980). For instance, description of food preparation can be in the form of a comprehensive cookbook; recipes are actually excellent ethnographic documents if correctly done (e.g., Anderson 2008). Many researchers will not want this level of comprehensive detail, but at least the reader should be able to understand the whole process described, in order to appreciate any conclusions reached.

Clearly, the fieldworker needs to record wider matters of culture, politics, and society. This requires attention to both local views and knowledge (or "beliefs") and modern international science (or "sciences"; Latour 2004). Traditional societies typically integrate, in one seamless system, ideas that social scientists would divide into "religious" versus "scientific"; it is essential to see these as part of one practical system of environmental management (Gonzalez 2001). The value of taking into account local views, ideas, emphases, and perceptions is shown by the few thorough and detailed "insider" ethnobiologies; most of these concern hunting and hunter-gatherer cultures, but see Bernard and Salinas Pedraza (1989) for a superb example from a farming society (the Nyahnyu of Mexico).

This contrast of “insider” and “outsider” is *not* the same as the contrast of “emic” and “etic” analysis, in spite of the constant and most unfortunate confusion of the two (e.g., in Kottak 2008). An emic analysis is an analysis in terms of an Indigenous local system. An etic analysis is one done using international measures. An emic study of agriculture looks at local systems and uses local measures; an etic one would be strictly in terms of international bioscience. Obviously, insiders can use etic measures as well as anyone; Mexican farmers, for instance, work and think in the metric system. Conversely, outsiders have their own emic systems, which they often misapply to local situations, under the delusion that their systems are etic. We have noted the problems of using culture-bound concepts of “horticulture” and “agriculture” as if they were etic concepts. Use of American emic concepts of “religion,” “superstition,” and “pseudoscience” as if they were etic ways of evaluating or classifying local beliefs is even more pernicious.

Finally, the day of the “lone wolf” ethnographer is over (see Pearsall and Hastorf, Turner and Nolan, and other chapters in this volume).

CONCLUSION

Ethnobiology has documented the sustainability, diversity, and viability of traditional agriculture and agricultural systems all over the world. Many of these systems have lower yields than modern agriculture, but are far more sustainable over time. One reason is that they are often more efficient in their use of energy and nutrients. Some—such as Yucatec Maya agriculture—actually outyield modern agriculture in their own environments.

Integration of traditional systems with modern scientific work, as in raised-bed horticulture, permaculture, and tree cropping (cf. Smith 1950), offers major prospects for a future where humanity can be fed without destroying the agricultural environment in the process. In a world where a billion people go to bed hungry every night (Collier 2007), and where agricultural land is suffering from desertification, urbanization, pollution, water shortage, and other increasing threats, solutions are needed, and ethnobiology can provide much of the necessary information.

REFERENCES

- AGELET A, BONET MA, VALLES J. Homegardens and their role as a main source of medicinal plants in mountain regions of Catalonia. *Econ Bot* 2000;54(3):295–310
- ANDERSON E. *Plants, man and life*. Berkeley: University of California Press; 1952.
- ANDERSON EN. Gardens in tropical America and tropical Asia. *Biotica* n.e. 1993a;1:81–102.
- ANDERSON EN. Southeast Asian gardens: nutrition, cash and ethnicity. *Biotica* n.e. 1993b;1:1–12.
- ANDERSON EN. *Ecologies of the heart*. Oxford: Oxford University Press; 1996.
- ANDERSON EN WITH CANUL JC, DZIB A, GUIDO SF, ISLEBE G, MEDINA TZUC F, SÁNCHEZ SÁNCHEZ O, CHALE PASTOR V. Those who bring the flowers: Maya ethnobotany in Quintana Roo, Mexico. By E. N. Anderson. Chetumal, Quintana Roo: ECOSUR; 2003.
- ANDERSON EN. *Everyone eats*. New York: New York University Press; 2005a.
- ANDERSON EN. Political ecology in a Yucatec Maya community. Tucson: University of Arizona Press; 2005b.
- ANDERSON EN. *Mayaland cuisine*. Self-published; available online from author; 2008.
- ANDERSON EN. The tropical food security garden. Available at www.krazykioti.com/articles/the-tropical-food-security-garden/; 2009.
- ANDERSON MK. *Tending the wild: Native American knowledge and the management of California's natural resources*. Berkeley: University of California Press; 2005.
- ANDERSON EN, ANDERSON ML. *Fishing in troubled waters*. Taipei: Orient Cultural Service; 1978.
- ANTHONY DW. *The horse, the wheel and language: How bronze-age riders from the Eurasian steppes shaped the modern world*. Princeton University Press; 2007.
- ARORA D, SHEPARD GH, JR, editors. Special mushroom issue. *Econ Bot* 2008;62:3.

- ATRAS S. Managing the Maya Commons: the value of local knowledge. In: NAZAREA V, editor. *Ethnoecology: situated knowledge/located lives*. Tucson: University of Arizona Press; 1999. p 190–214.
- BALÉE W. *Footprints of the forest*. New York: Columbia University Press; 1994.
- BALTER M. The tangled roots of agriculture. *Science* 2010; 327:404–406.
- BARFIELD TJ. *The perilous frontier: nomadic empires and China, 221 BC to AD 1757*. Cambridge (MA): Blackwell; 1989.
- BARKER G. *The agricultural revolution in prehistory*. Oxford: Oxford University Press; 2006.
- BARLETT P, editor. *Agricultural decision making: anthropological contributions to rural development*. New York: Academic Press; 1980.
- BARLETT P. *Agricultural choice and change: decision-making in a Costa Rican community*. New Brunswick (NJ): Rutgers; 1982.
- BEAN LJ, SAUBEL KS. *Temalpakh: Cahuilla Indian knowledge and usage of plants*. Banning (CA): Malki Museum Press; 1972.
- BELLWOOD P. The dispersals of established food-producing populations. *Curr Anthropol* 2009;50:621–626.
- BELLWOOD P, RENFREW C, editors. *Examining the farming/language dispersal hypothesis*. Cambridge: McDonald Institute Monographs; 2002.
- BENNETT J. *Of time and the enterprise: North American family farm management in a context of resource marginality*. Minneapolis: University of Minnesota Press; 1982.
- BENZ B, PERALES H, BRUSH S. Tzeltal and Tzotzil farmer knowledge and maize diversity in Chiapas, Mexico. *Curr Anthropol* 2007;48:289–300.
- BERKES F. *Sacred ecology: traditional ecological knowledge and resource management*. Philadelphia: Taylor and Francis; 1999.
- BERNARD HR. *Research methods in anthropology*. 4th ed. Lanham (MD): AltaMira (Rowman and Littlefield); 2006.
- BERNARD HR, PEDRAZA JS. *Native ethnography: a Mexican Indian describes his culture*. Newbury Park (CA): Sage; 1989.
- BLACKBURN T, ANDERSON K, editors. *Before the wilderness*. Socorro (NM): Ballena Press; 1993.
- BOST JHP. Program. *50th Annual Meeting of the Society for Economic Botany*. Charleston (SC): Society for Economic Botany; 2009. p 32–33.
- BROOKFIELD H, PADOCH C, PARSONS H, STOCKING MA, editors. *Cultivating biodiversity: understanding, analysing and using agrodiversity*. Rugby: Practical Action Publishing; 2002.
- CHANG KC. *Food in Chinese culture*. New Haven (CT): Yale University Press; 1977.
- CHILDE VG. *What happened in history*. Harmondsworth: Pelican; 1954.
- CLEMENT CR. 1492 and the loss of Amazonian crop genetic resources. I: The relation between domestication and human population decline. *Econ Bot* 1999;53:188–202.
- CLEVELAND D, SOLERI D. *Food from dryland gardens: an ecological, nutritional and social approach to small-scale household food production*. Tucson (AZ): Center for People, Food and Environment; 1991.
- COHEN MN, editor. *Rethinking the origins of agriculture (special section)*. *Curr Anthropol* 2009;50:5:585–712.
- COLLIER P. *The bottom billion: why the poorest countries are failing and what can be done about it*. New York: Oxford University Press; 2007.
- CONKLIN HC. *Hanunoo agriculture*. Rome: Food and Agriculture Organization of the United Nations; 1957.
- CONKLIN HC. *Ethnographic atlas of Ifugao: a study of environment, culture, and society in Northern Luzon*. New Haven (CT): Yale University Press; 1981.
- CONKLIN HC. *Fine description*. In: KUIPERS J, MCDERMOTT R, editors. *Monograph 56*. New Haven (CT): Yale Southeast Asia Studies; 2007.
- CUERO D. *The autobiography of Delfina Cuero, as told to Florence Shipek*. Banning, CA: Malki Museum Press; 1970.
- CUSHING F. *Zuni breadstuffs*. *Indian Notes and Monographs VII*. New York: Museum of the American Indian (Heye Foundation); 1920. p 7–642.
- DENHAM T, WHITE P, editors. *The emergence of agriculture*. 2nd ed. Abingdon (UK): Routledge; 2007.
- DENHAM T, IRIARTE J, VRYDAGHS L, editors. *Rethinking agriculture: archaeological and ethnoarchaeological perspectives*. Walnut Creek (CA): Left Coast Press; 2007.
- DEUR D, TURNER NJ, editors. *Keeping it living: traditions of plant use and cultivation on the Northwest Coast of North America*. Seattle and Vancouver: University of Washington Press, and University of British Columbia Press; 2005.
- DEWALT K, DEWALT B. *Participant observation: a guide for fieldworkers*. Walnut Creek (CA): AltaMira; 2001.
- DOVE M. *The agronomy of memory and the memory of agronomy: ritual conservation of archaic cultigens in contemporary farming systems*. In: NAZAREA V, editor. *Ethnoecology: situated knowledge/located lives*. Tucson: University of Arizona Press; 1999. p 45–70.
- EYZAGUIRRE PB, LINARES OF, editors. *Home gardens and agrobiodiversity*. Washington (DC): Smithsonian Institution; 2004.
- FAUST BB. *Mexican rural development and the plumed serpent*. Westport (CT): Greenwood; 1998.
- FEDICK S, editor. *The managed mosaic: ancient Maya agriculture and resource use*. Salt Lake City: University of Utah Press; 1996.
- FELGER R, MOSER M. *People of the desert and sea: ethnobotany of the Seri*. Tucson: University of Arizona Press; 1985.
- FINERMAN R, SACKETT R. *Using home gardens to decipher health and healing in the Andes*. *Med Anthropol Quart* 2003;17:459–482.
- FORD A, EMERY K, editors. *Exploring the legacy of the Maya Forest (Introduction)*. Special issue. *J Ethnobiol* 2008; 28(2):147–153.

- FRAKE C. Language and cultural description. DIL AS, editor. Stanford (CA): Stanford University Press; 1980.
- GELLES P. Water and power in Highland Peru: the cultural politics of irrigation and development. New Brunswick (NJ): Rutgers University Press; 2000.
- GLADWIN C. A model of farmers' decisions to adopt the recommendations of Plan Puebla [PhD dissertation]. Stanford (CA): Food Research Institute, Stanford University; 1977.
- GLADWIN C. Ethnographic decision tree modeling. Newbury Park, CA: Sage; 1989.
- GOLSON J. The origins and development of New Guinea agriculture. In: DENHAM T, WHITE P, editors. The emergence of agriculture: a global view. London: Routledge. 2007 [1989]. p 175–186.
- GÓMEZ-POMPA A. On Maya silviculture. *Mex Stud/Estud Mex* 1987;3:1:1–17.
- GÓMEZ-POMPA A, ALLEN M, FEDICK S, JIMÉNEZ-OSORNO J, editors. The Lowland Maya area: three millennia at the human–wildland interface. New York: Haworth Press; 2003.
- HARLAN J. Crops and Man. 2nd ed. Madison (WI): American Society of Agronomy and Crop Science Society of America; 1992.
- HARLAN J. The living fields: our agricultural heritage. Cambridge: Cambridge University Press; 1995.
- HEDRICK K. Our way of life: identity, landscape, and conflict [PhD thesis]. Riverside: Department of Anthropology, University of California; 2007.
- HEGGARTY P, BERESFORD-JONES D. Agriculture and language dispersals. *Curr Anthropol* 2010;51:163–191.
- HILL J. Proto-Uto-Aztecan: a community of cultivators in Central Mexico? *Amer Anthropol* 2001;103:913–934.
- HUANG HT. Science and civilisation in China. Volume 6: Biology and biological technology. Part V: Fermentations and food science. Cambridge: Cambridge University Press; 2000.
- HUBER T. The cult of pure crystal mountain. New York: Oxford University Press; 1999.
- HUNN E. N'Chi-Wana, the Big River. Seattle: University of Washington Press; 1990.
- HUNN E. A Zapotec natural history: trees, herbs, and flowers, birds, beasts and bugs in the life of San Juan Gbëë. Tucson: University of Arizona Press; 2008.
- INGOLD T. The perception of the environment: essays in livelihood, dwelling and skill. London: Routledge; 2000.
- KIVI A. Seven brothers. New York: Finnish–American Translators Association; 1991.
- KLEE G, editor. World systems of traditional resource management. New York: V.H. Winston and Sons; 1980.
- KOTTAK C. Cultural anthropology. 13th ed. New York: McGraw-Hill; 2008.
- LACY SM, CLEVELAND D, SOLERI D. Farmer choice of sorghum varieties in Southern Mali. *Hum Ecol* 2006; 34:331–353.
- LAIRD C. The Chemehuevis. Banning (CA): Malki Museum Press; 1976.
- LANSING S. Priests and programmers: technologies of power in the engineered landscape of Bali. Princeton (NJ): Princeton University Press; 1991.
- LANSING S. Perfect order: recognizing complexity in Bali. Princeton (NJ): Princeton University Press; 2006.
- LATHRAP DW. Our father the cayman, our mother the gourd: Spinden revisited, or a unitary model for the emergence of agriculture in the New World. In: REED CA, editor. Origins of Agriculture. Hague: Mouton; 1977. p 713–752.
- LATOUR B. Politics of nature: how to bring the sciences into democracy (trans. PORTER C). Cambridge (MA): Harvard University Press; 2004.
- LAWTON HW, WILKE PJ, DEDECKER M, MASON WM. Agriculture among the Paiute of Owens Valley. *J Calif Anthropol* 1976;3:13–51.
- LUBINSKY P, HERNÁNDEZ S, HERNÁNDEZ J, KIM S-C, GÓMEZ-POMPA A. Origins and dispersal of cultivated vanilla (*Vanilla planifolia* Jacks. [Orchidaceae]). *Econ Bot* 2008; 62:127–138.
- MACNEISH RS. The origins of agriculture and settled life. Norman: University of Oklahoma Press; 1991.
- MANNING R. Against the grain: how agriculture has hijacked civilization. Berkeley (CA): North Point Press; 2005.
- MARCUS J, STANISH C, editors. Agricultural strategies. Los Angeles: Cotsen Institute of Archaeology, UCLA; 2006.
- MARTEN G, editor. Traditional agriculture in southeast Asia. Honolulu: East–West Center; 1986.
- MARTIN G. Ethnobotany. People and plants conservation manuals 1. London: Chapman and Hall; 2004.
- MCCRACKEN G. The long interview. Newbury Park (CA): Sage; 1988.
- MCGUIRE SJ. Vulnerability in farmer seed systems: farmer practices for coping with seed insecurity for sorghum in Eastern Ethiopia. *Econ Bot* 2007;61:211–222.
- MORGAN LH. Ancient society. New York: Henry Holt; 1877.
- NABHAN G. Gathering the desert. Tucson: University of Arizona Press; 1987.
- NABHAN G. Cultures of habitat: on nature, culture and story. Washington (DC): Counterpoint; 1997.
- NATIONAL ACADEMY OF SCIENCES. The winged bean: a high-protein crop for the Tropics. Washington (DC): National Research Council; 1975.
- NATIONAL ACADEMY OF SCIENCES. Lost Crops of the Incas. Washington (DC): National Research Council; 1989.
- NATIONAL ACADEMY OF SCIENCES. Lost Crops of Africa. Volume I: Grains. Washington (DC): National Research Council; 1996.
- NATIONAL ACADEMY OF SCIENCES. Lost Crops of Africa. Volume II: Vegetables. Washington (DC): National Research Council; 2006.
- NAZAREA V, editor. Ethnoecology: situated knowledge/located lives. Tucson: University of Arizona Press; 1999.
- PIPER C. The soybean. New York: McGraw-Hill; 1923.
- PIPERNO DR, PEARSALL DM. The origins of agriculture in the lowland neotropics. New York: Academic Press; 1998.
- POLLOCK NJ. These roots remain: food habits in islands of the Central and Eastern Pacific since Western contact. Honolulu: University of Hawaii Press; 1992.

- POSEY DA. Indigenous knowledge and ethics: a Darrell Posey reader. New York: Routledge; 2004.
- QUINLAN MB. From the bush: the front line of health care in a Caribbean village. Belmont (CA): Thomson Wadsworth; 2004.
- RANDALL RA. Change and variation in Samal fishing: making plans to “make a living” in the southern Philippines [PhD thesis]. Berkeley: Department of Anthropology, University of California; 1977.
- RAPPAPORT RA. Pigs for the ancestors. 2nd ed. New Haven (CT): Yale University Press; 1984.
- RE CRUZ A. The two milpas of Chan Kom: a study of socio-economic and political transformations in a Maya community. Albany (NY): SUNY; 1996.
- REED RK. Prophets of agroforestry: Guarani communities and commercial gathering. Austin: University of Texas Press; 1995.
- REMMERS GGA. Con cojones y maestría. Amsterdam: Thela; 1998.
- RIPE C. Dying of starvation at the supermarket [unpublished MS]. 1994.
- SAUER C. Agricultural origins and dispersals. New York: American Geographic Society; 1952.
- SHIPEK F. An example of intensive plant husbandry: the Kumeyaay of Southern California. In: HARRIS DR, HILLMAN GC, editors. Foraging and farming: the evolution of plant exploitation. Cambridge: Cambridge University Press; 1989. p 159–170.
- SMITH JR. Tree crops: a permanent agriculture. New York: Devin-Adair; 1950.
- SPENCER JE. Shifting cultivation in southeast Asia. Berkeley: University of California Press; 1966.
- STEARMAN AM. The Yuquí connection: another look at Sirionó deculturation. *Amer Anthropol* 1984;86:630–650.
- STEWART J. Theory of culture change. Urbana: University of Illinois Press; 1955.
- STEWART OC, LEWIS H, ANDERSON K. Forgotten fires: native Americans and the transient wilderness. Norman (OK): University of Oklahoma Press; 2002.
- STILES D. Tubers and Tenrecs: the Mikea of southwest Madagascar. *Ethnology* 1991;30:251–263.
- STUART J. Subsistence ecology of the Isthmus Nahuat Indians of Southern Veracruz, Mexico [PhD dissertation]. Riverside: Department of Anthropology, University of California; 1978.
- TERÁN S, RASMUSSEN CH. La milpa de los Mayas. Mérida: author publication; 1993.
- TERÁN S, RASMUSSEN CH, CAUICH OM. Las plantas de la milpa entre los Mayas. Mérida: Fundación Tun Ben Kin; 1998.
- TURNER BL II, BRUSH SB, editors. Comparative farming systems. New York: Guilford Press; 1987.
- TURNER N. Earth’s blanket. Vancouver: University of British Columbia; 2005.
- VOGT EZ. Fieldwork among the Maya: reflections on the Harvard Chiapas project. Albuquerque: University of New Mexico Press; 1994.
- WANDSNIDER L. The roasted and the boiled: food composition and heat treatment with special emphasis on pit-hearth cooking. *J Anthropol Archaeol* 1997;16:1–48.
- WEBER SA. Out of Africa: the initial impact of millets in South Asia. *Curr Anthropol* 1998;39:267–274.
- WEBER SA, BELCHER WR, editors. Indus ethnobiology: new perspectives from the field. Lanham (MD): Lexington Books; 2003.
- WILKEN G. Good farmers. Berkeley: University of California Press; 1987.
- WILLIAMS NM, HUNN ES, editors. Resource managers: North American and Australian hunter-gatherers. Canberra: Australian Institute of Aboriginal Studies; 1982.
- WINTER JC, editor. Tobacco use by Native North Americans: sacred smoke and silent killer. Norman: University of Oklahoma Press; 2000.
- ZEDER M. The Neolithic macro-(r)evolution: macroevolutionary theory and the study of culture change. *J Archaeol Res* 2008;17:1–64.
- ZEDER M, HESSE B. The initial domestication of goats (*Capra hircus*) in the Zagros Mountains 10,000 years ago. *Science* 2000;287:2254–2257.
- ZEDER MA, BRADLEY DG, EMSHWILLER E, SMITH BD, editors. Documenting domestication: new genetic and archaeological paradigms. Berkeley: University of California Press; 2007.

Chapter 19

Linguistic Ethnobiology

EUGENE S. HUNN

Department of Anthropology, University of Washington, Seattle, Washington

CECIL H. BROWN

Department of Anthropology, University of Northern Illinois, DeKalb, IL

NAMES, THE FOUNDATION OF LINGUISTIC ETHNOBIOLOGY	319
WHAT NAMES TELL US	320
WHAT NAMES NAME	322
NAMES AND PREHISTORY	323
CLASSIFICATIONS, FOLK AND SCIENTIFIC	325
THE PERCEPTUAL-TAXONOMIC THEORY	325
DIFFERENCES IN FOLK CLASSIFICATION AND NOMENCLATURE ACROSS SOCIETAL TYPES	329
COMPARING FOLK WITH LINNAEAN (SCIENTIFIC) CLASSIFICATION	331
REFERENCES	332

There are some 6000 languages spoken across the globe. Language is a complex code integrating sounds, words, and meanings so that perception, memory, intention, and imagination can be communicated among a people. In addition, through language humans manage their relationships with the cultural and natural things they encounter. In this chapter, we consider how people use language to *name* the culturally important biological elements of the world they inhabit. The study of the naming of plants and animals is called linguistic ethnobiology.

NAMES, THE FOUNDATION OF LINGUISTIC ETHNOBIOLOGY

Fieldwork in linguistic ethnobiology typically commences with questions directed toward learning the names people use to talk about plants and animals. This can be done by

simply pointing at an example of a plant or animal and asking, “What is this?” Very rapidly, using this simple method, a fieldworker can collect many words for biological organisms in an unfamiliar language. However, this approach is problematic. For example, in Zapotec—the language of a people of Mexico studied by Hunn (2008)—one might ask, pointing to a tall prickly-pear cactus, *Zha lë ri?* “What is the name of this one?” The answer might be *yag-biaa-nquits*. From this response one could draw several different conclusions: *yag-biaa-nquits* designates (1) cactus, or (2) prickly-pear cactus, or (3) tree, or (4) thorny plant. The fieldworker must then proceed carefully, through more detailed questioning, to determine the precise referent. This, hopefully, will lead to the correct understanding that the Zapotec reply is best translated as “white prickly-pear cactus tree/shrub” and that this name refers specifically to *Opuntia robusta* x *O. ficus-indica*, a domesticated hybrid of two Mexican species of the prickly-pear genus *Opuntia*, one genus among many of the cactus family.

Opuntia robusta x *O. ficus-indica* is a name for the Zapotec plant from the scientific naming system developed in the eighteenth century by Linnaeus. Ideally, all plant and animal species around the world have scientific names. While not perfect, Linnaean names constitute the best available system for accurately referring to species of plants and animals regardless of how these are named in individual human languages.

The fieldworker should not assume that a people will have a specific name for every living thing in their environment. The great majority of beetles—of which there exists an impressively large variety in virtually every terrestrial environment—will go unnamed in most languages, as is the case in both English and Zapotec. When a name for a species does not pertain to a language, a speaker, for whatever reason, may nonetheless provide a fieldworker with an *ad hoc* designation. Consequently, investigators must learn to differentiate made-up, often descriptive terms from true, widely acknowledged names.

This can be fairly straightforward for English. For example, a blue bird (primary stress on bird) is typically something quite different than a Bluebird (primary stress on blue). An Indigo Bunting, by virtue of its coloration, is a blue bird, but not a Bluebird, while *Sialia sialis* (Eastern Bluebird), by virtue of its kind, is a Bluebird, though the female is more gray than blue. In contrast, the Zapotec situation is more difficult. For example, *guiee-nquits* “white flower,” *guiee-nguets* “yellow flower,” and *guiee-morad* “purple flower” are each sometimes simple descriptions and, thus, applicable to any flower of the appropriate color, but in other contexts are true names for individual species. In Zapotec these usages are not differentiated by stress or some other linguistic feature as they are in English.

Ethnobiological systems of peoples of traditional agricultural societies typically show names for several hundred species of plants and several hundred species of animals. This was first noted by the cultural anthropologist Claude Lévi-Strauss (1966: 153–154), who suggests that 300–600 terms may represent a “threshold corresponding roughly to the capacity of memory . . .” Later, Brent Berlin (1994: 96–101) dubbed this “nature’s Fortune 500.”

What Names Tell Us

In theory, words are arbitrary signs, which mean what they mean by virtue of social consensus (Saussure 1983). The meanings of words, unlike sentences, cannot be inferred from the meanings of their constituent elements. However, some words, typically compound ones, may exhibit *descriptive force*, hinting at the nature of the thing named, without being entirely semantically transparent. For example, a White Oak is in some sense white, but exactly how?

Most likely the attributive “white” alludes to the pale color of the wood of the prototypical White Oak (*Quercus alba*). The term has since been extended to refer to a subgenus of oaks, *Leucobalanus*, the species of which share certain technical features, usually but not necessarily including whitish wood. The name *white oak* also implies that it refers to a kind of oak.

Harold Conklin (1962) and Brent Berlin (Berlin et al. 1974: 28–29) suggest typologies of biological names as useful starting points for understanding details of nomenclature applied to plants and animals. Conklin distinguishes *unitary* and *composite* biological lexemes or labels. Composite labels are also called *binomial* terms (or polynomial if generalized), these being compound words that include as a head term the name of a category superordinate to that named by the label plus an attributive that qualifies the head, for example, White Oak, a kind of oak. Unitary lexemes may be *simple* or *compound*. Cobra is a simple unitary lexeme. Copperhead is a compound unitary lexeme. A Copperhead (snake) is not a kind of head, thus the name is compound but not composite, in Conklin’s terminology.

Berlin refines Conklin’s system to distinguish two types of composite lexemes. The first are *productive primary* lexemes, such as *tulip tree* and *mockingbird*, with head terms that designate the more inclusive categories tree and bird respectively. Such names contrast directly with unitary labels (i.e., *primary* lexemes in Berlin’s scheme) such as *oak* and *robin*. These compound terms might be called *generic binomials*, since they label what Berlin defines as *folk generic taxa*. (*Taxon* is another word for category, plural *taxa*.) Berlin’s *secondary* lexemes (what might be called *specific* or *varietal binomials*) denote *folk-specific taxa*. White Oak contrasts with Black Oak, Red Oak, and Pin Oak, all kinds of the folk generic taxon oak that are folk-specific taxa. Great Horned Owl contrasts with Snowy Owl, Screech Owl, and Saw-whet Owl, all kinds of the folk generic taxon owl that label folk-specific taxa. Secondary lexemes, according to Berlin, provide reliable evidence that the categories so-named are members of the *folk-specific rank* (see discussion of ranks below).

Languages vary a great deal in how they form names for plants and animals. Binomials may be abbreviated in certain contexts, or the head terms may be optional. For example, the Swallowtail Butterfly might more often be called simply a *swallowtail*. In such cases it may be difficult to decide if *butterfly* is a label for a folk genus or a more inclusive life-form class like those categories labeled by *tree* or *fish* in English. In any case, we know for certain that a butterfly is not a kind of fly. Such *pseudo-binomials* set traps for the unwary linguistic ethnobiologist. A second common pattern is for the *prototypical* species of a folk genus to be known simply by the genus name. Only less typical members of the genus are specifically differentiated. We speak of *cats*, understanding the name to apply to the domestic house cat, not to a wild cat such as the Bobcat. The word *cat* names two quite distinct concepts, the house cat and a more general category of felines that includes bobcats, lynxes, and lions. For clarity in linguistic ethnobiology we can distinguish these as cat_1 and cat_2 . The former category is “nested” in the latter since cat_1 is necessarily a kind of cat_2 .

Even the simplest names may have descriptive force. Many bird names, for example, are *onomatopoetic*, that is, they imitate a characteristic sound of the bird named. *Owl* is an example, although this name is so familiar we may not think of it as descriptive. Other onomatopoetic names are complex, with analyzable constituents, such as *killdeer* or *whip-poor-will*. If one were to encounter such names in an unfamiliar language, these might not be thought to be onomatopoetic at all. For example, the Tzeltal Mayan name for the great horned owl (*Bubo virginianus*) is *tuh-kulum-pukuh*, literally “stink of the devil” (Hunn 1977: 161), but despite its analyzability it is nonetheless clearly a rendition of this owl’s call.

What Names Name

Names for biological things differ from personal names and names for pets such as *John* and *Rover* since they do not designate just a unique individual or entity. Rather, these names denote exemplars of categories of organisms. For example, the word *tree* can be used to refer to a specific tree, for example, a particular White Oak. This identified tree is not the only biological entity in the world to which the word *tree* is appropriately applied, since the word can be used to designate not only any one of all White Oaks, or any one of all oaks, but also all other botanical organisms people generally think of as being trees, such as pines, firs, and maples. Such names, then, not only serve to refer to things, but also flag those organisms considered to be similar (or, perhaps, even the same) by people who use the words. In linguistic ethnobiology, organisms sharing a name, such as *tree*, *oak*, or *white oak*, respectively constitute a biological category or taxon.

When two or more names refer to things of the same category, these names are *synonyms*. For example, Cottonmouth and Water Moccasin are synonyms since both names refer to the same species of snake, *Agkistrodon piscivorus*. *Polysemy* (a special case of *homonymy*) is the opposite of synonymy, where a single name is associated with two or more distinct categories or concepts that are nonetheless related in some manner. An extreme example is the English word *man*. Depending on context, this may refer to any individual of the species *Homo sapiens*. More typically it refers to the male of that species, although it might be used to single out adult males, that is, “men from boys.” Finally, *man* may refer to “real men,” that is, those exhibiting certain exemplary masculine qualities of strength or assertiveness. These four polysemous uses of the word can be identified as man_1 , man_2 , man_3 , or man_4 .

Polysemous usage may reflect idiosyncratic or dialectical variation. For example, many English speakers call wasps *bees*, applying that term more broadly than speakers who consider bees to be quite different from wasps, although perhaps closely related. Some American English-speakers use the term *pine* to refer exclusively to trees of the genus *Pinus*; others apply the term more widely to include various trees of the family Pinaceae, including firs, spruce, and hemlocks. These variants might be distinguished as bee_1 and bee_2 or $pine_1$ and $pine_2$. Polysemy need not implicate just nested concepts such as the latter, but suggest metaphorical associations. For example, *dolphin*, which is most widely understood as denoting a small cetacean much like a porpoise, also designates a kind of tropical sport fish one often encounters on a restaurant menu. Apparently, these two marine creatures demonstrate some superficial resemblance to one another. (However, this usage may be fast disappearing since people are not inclined to order dolphin as a meal; consequently, *dolphin* apparently is being replaced by a less discomforting term for this seafood item, i.e., by *mahi-mahi*.)

Polysemy also includes cases such as *poison oak* and *silverfish*. These are what Hunn calls *pseudo-binomials*. Taken literally, one might presume that *poison oak* designates a kind of oak, or *silverfish*, a kind of fish. Poison oak is not a kind of oak, such as is a White Oak, and a silverfish is not kind of fish, such as is an Ocean Sunfish. The associations between oak and poison oak and between fish and silverfish are metaphorical, implying that poison oaks are somehow like oaks, although not really oaks, and that silverfish are somehow like fish, although not really fish. The leaf of a poison oak plant resembles the leaves of certain species of oak. The silverfish is a primitive insect (*Lepisma saccharina*, order Thysanura), a household pest of cool, damp situations. The creature apparently is reminiscent of a tiny slithery fish.

Linguistic ethnobiologists have identified biological categories that are not named in languages but nevertheless are of significance to people. These have been dubbed *covert categories*. Apparently, people who speak the same language can all share a category without sharing a name for exemplars of that category. Researchers have demonstrated the existence of covert categories by having people sort plant or animal names written on cards into piles based on the similarity of the things named. When different names are consistently sorted together in a single pile, this can be taken as evidence of a covert category when the names designate organisms that do not have some name in common. Covert categories can also become evident when locals occasionally misapply a name to a plant or animal, but do so in patterned ways. Terence Hays observed such patterns in naming plants by the Ndumba people of Papua New Guinea (Hays 1974). An example of a covert category familiar to speakers of English is that of dogs, coyotes, and wolves. Creatures of these three categories “go together” for many speakers. While there is an English word that groups these together, that is, *canine*, it is not an everyday word known and used by all speakers (rather it is a specialist or educated term). Berlin writes of an *intermediate* taxonomic rank between his folk generic and life-form ranks (see below). Most such intermediates are covert and discoverable only by special tasks such as the pile sort.

Names and Prehistory

Because plant and animal names of long-extinct languages can be reconstructed using the comparative method of historical linguistics, we can also appreciate perspectives on the natural world of peoples who lived in the prehistoric past. Tools of historical linguistics are used by Brown (2006a,b, 2010a) in a series of recent studies to reconstruct words for important plants occurring in proto-languages. Proto-languages are reconstructed codes inferred from modern languages, for example, Proto-Indo-European, the parent language to modern English, Spanish, Irish, Greek, and Hindi (among others). Reconstructed names for living things show which plants and animals were important to peoples of prehistory.

An early effort to integrate ethnobiology and historical linguistics is an important study by Berlin et al. (1973). In this work, plant names are collected from speakers of Tzeltal and Tzotzil, two Mayan languages of Chiapas, Mexico. These two languages are genetically related since both are directly descended from a common ancestral language, Proto-Tzeltalan. Plant names found in each of the two languages that refer to the same respective species are compared for phonological similarity. If two corresponding words for a species are phonologically similar, the two words may be cognate, meaning that both have developed from a single name in Proto-Tzeltalan that designated the plant in question. For example, Tzeltal *may* and Tzotzil *moy* both designate *Nicotiana tabacum* L. (tobacco) and are phonologically similar. Berlin et al. (1973: 155) regard these as cognates, both of which have developed from a Proto-Tzeltalan word for the species (which is reconstructed by them using the comparative method as **mAy*).

Plant species designated by pairs of names, one each from Tzeltal and Tzotzil respectively, are grouped by Berlin et al. (1973) into four categories delimiting their cultural significance (from high to low): (1) cultivated plants; (2) protected plants; (3) wild-useful plants; and (4) wild-insignificant plants. A total of 257 plant species have both Tzeltal and Tzotzil names (1973: 161). Of these, 111 are designated by pairs of cognate terms attesting to a plant term’s pertinence to the Proto-Tzeltalan lexicon. Paired terms for 146 species are found not to be cognate: 14 pairs pertaining to cultivated plants are found cognate and 2 are non-cognate; 29 pairs pertaining to protected plants are cognate and 7 are non-cognate;

52 pairs pertaining to wild-useful plants are cognate and 63 are non-cognate; and 16 pairs pertaining to wild-insignificant plants are cognate and 74 non-cognate.

The correlation between cognation and cultural significance is extremely robust and statistically significant: $\gamma = 0.97$ (on a scale from 0.00 to 1.00, where 0.00 indicates no association whatsoever and 1.00 is a perfect correlation), $p < .001$. Plant names of Proto-Tzeltalan have strongly tended to be retained by its offspring languages when the designated plants are high in cultural importance, and replaced when of lesser significance.

Brown's (2006a,b, 2010a) research focuses on the names of plants that reconstruct for proto-languages of the New World, especially those pertaining to the prehistory of North America (Mexico, USA, and Canada). Special attention is given to native plants that in historical times have traditionally been managed by Native American peoples.

The implication of the Berlin et al. (1973) study for Brown's work is that plants with names that can be reconstructed were of substantial cultural significance for speakers of those ancestral languages. Lack of a reconstructed name in a proto-language suggests that the organism was not sufficiently important for its name to have persisted.

Glottochronology is a method devised in the mid-twentieth century to calculate when a proto-language might have been spoken. In a study of the development of agriculture in prehistoric Mesoamerica, Brown (2010a) applies a glottochronological method that uses a computer-based, automated procedure to calculate dates for 30 Mesoamerican proto-languages. For example, Proto-Tzeltalan is calculated to have been last spoken some 795 years BP (before present). We may plausibly conclude that *Nicotiana tabacum* L. (tobacco) and other plants for which names reconstruct for Proto-Tzeltalan were of substantial cultural significance some 800 years ago.

Brown (2010a) is able to determine when certain managed plants first became significant to Mesoamerican groups. For example, he finds that terms for *Zea mays* (maize) reconstruct for all 30 Mesoamerican proto-languages. The glottochronological date for the oldest of these 30 ancestral languages, Proto-Otomanguean, is 7034 BP. This indicates that maize was of significance to at least one group of Mesoamerican people at least 7000 years ago. Brown's research focuses on 41 plants which are today widely cultivated or protected by Native Americans of Mesoamerica. Table 19.1 is a listing of 11 of the better known of

Table 19.1 Better-Known Managed Plants of Mesoamerica Ranked-Ordered by Glottochronological Date from Oldest to Youngest¹

Common English name	Scientific identification	Oldest date (in years before present)
Maize	<i>Zea mays</i>	7034 BP
Squash	<i>Cucurbita</i> spp.	7034 BP
Chili pepper	<i>Capsicum</i> spp.	4868 BP
Sweet potato	<i>Ipomoea batatas</i>	4387 BP
Tobacco	<i>Nicotiana tabacum</i>	3712 BP
Cotton	<i>Gossypium hirsutum</i>	3612 BP
Chocolate (cacao)	<i>Theobroma cacao</i>	3350 BP
Common bean	<i>Phaseolus vulgaris</i>	3350 BP
Papaya	<i>Carica papaya</i>	2659 BP
Pineapple	<i>Ananas comosus</i>	2455 BP
Lima bean	<i>Phaseolus lunatus</i>	2400 BP

¹Table adapted from Brown (2010a).

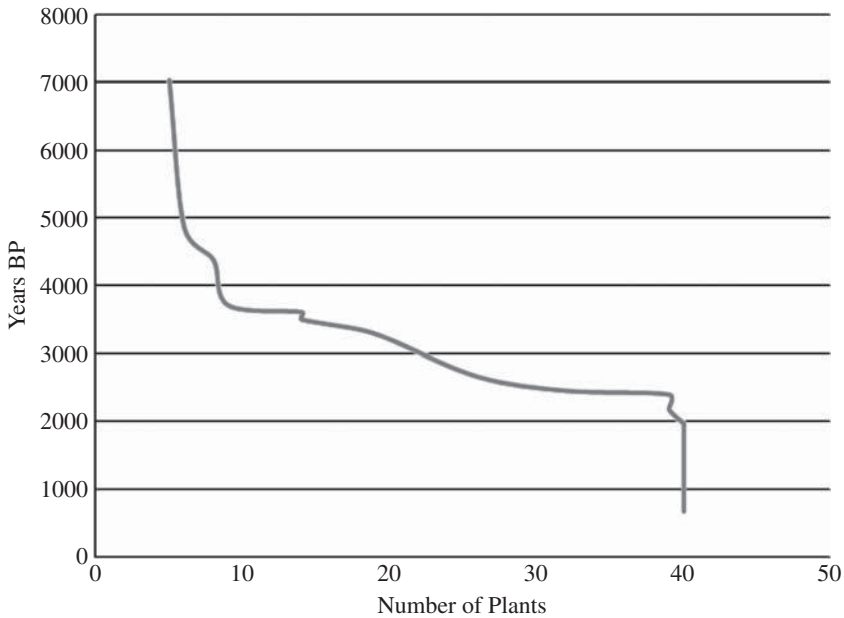


Figure 19.1 Association of the number of cultivated/protected plants named in Mesoamerican proto-languages in general with years before present. Figure by Brown (2010a).

these 41 plants, ranked-ordered according to oldest glottochronological date, from earliest to latest.

Brown's linguistic results dovetail with findings from paleoethnobotanical studies undertaken by archaeologists. For example, it is now well established in the archaeological record and by plant geneticists as well that both maize and squash are among the earliest plants to have been domesticated in Mesoamerica. Names for these two plants reconstruct for the proto-language showing the oldest glottochronological date among ancestral languages of Mesoamerica.

Figure 19.1 graphically illustrates that from about 7000 BP to around 3500 BP there is a slow but steady increase in the number of different plant species for which names reconstruct for Mesoamerican proto-languages. At around 3500 BP we note an explosion in the number of plants for which names reconstruct. The date of 3500 BP corresponds with the archaeologically documented period when a village-farming way of life was becoming well established in prehistoric Mesoamerica.

CLASSIFICATIONS, FOLK AND SCIENTIFIC

The Perceptual-Taxonomic Theory

As noted earlier, ethnobiological inventories of human groups, as reflected by their names for organisms, can range into the hundreds for both plants and animals. While it is possible that these could be stored in the memory as simple lists, such a strategy seems improbable given the information management complications it would impose. Ethnobiologists have proposed instead that biological data is organized in the heads of people as a taxonomic hierarchy grounded in perceived relations of overall similarity and difference.

Scientific or Linnaean classification is the model for such a proposal. However, unlike the biological taxonomies of local groups, referred to as *folk-taxonomies*, scientific classification deals with all the living things of the world and must, therefore, accommodate millions of species organized within thousands of higher taxa related through “kind of” relations or relations of hierarchic inclusion. The Linnaean taxonomic hierarchy includes seven obligatory ranks (kingdom, phylum/division, class, order, family, genus, and species) plus many more intercalary optional ranks, as needed. Folkbiological taxonomies are, by comparison, very shallow.

A folk-taxonomic structure is a set of categories or taxa arranged so that every taxon is included within one and only one higher order class, up to the *unique beginner* or *kingdom* category, designated respectively by *plant* and *animal* in English folk-taxonomies. This structure resembles that of a tree (every twig is attached to one and only one branch, although each branch may give rise to numerous twigs) and may be called a *taxonomic tree*, although it is usually depicted upside-down, with the trunk above (the *kingdom*) and the twigs below (*terminal taxa*) (see Fig. 19.2). Each branching joint is a *node* in the taxonomic structure and constitutes a taxon that includes all subsidiary taxa. Unless covert, each such node is named. This formal structure requires one further specification. Taxa must be assigned to one and only one *taxonomic rank* (Kay 1971).

The most widely cited interpretation of taxonomic ranks is that provided by Berlin (1992: 13–20). He defines six universal ranks (see Fig. 19.2). The most basic rank is the *folk generic*. The least complex taxonomy would consist of an inventory of several hundred such generic taxa immediately included in a plant or animal kingdom (assuming that a language provides a name for plant and/or animal as is often not the case). Generic taxa are defined as logically *general* and perceptually *salient*. Each generic taxon is *polythetic*, distinguished from all other generic taxa by several to many characteristics, and each is recognized by a distinct *gestalt*, meaning that exemplars of the category come to mind as a picture of the entire plant or animal. A corollary of these properties is that each generic taxon is likely to correspond with some phylogenetically recognized scientific taxon,

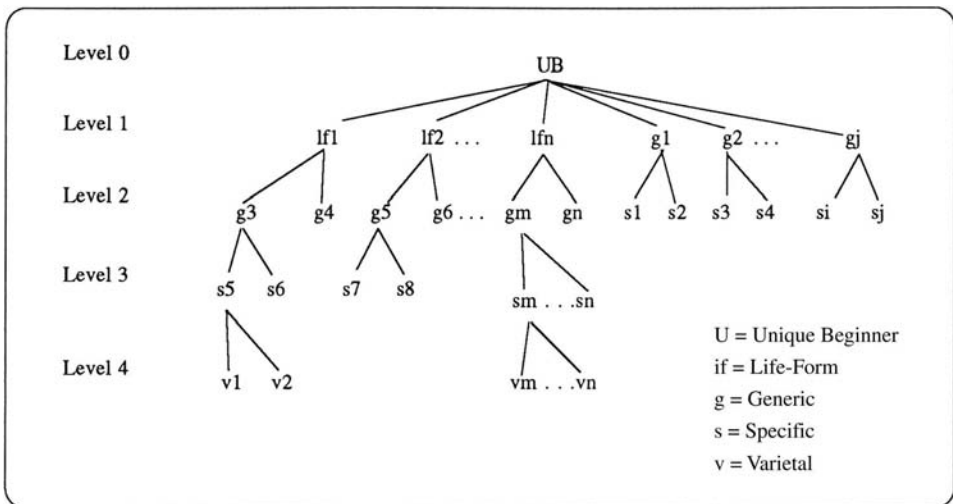


Figure 19.2 Schematic relationship of five of the six proposed universal ethnobiological ranks (née categories) and their relative hierarchic positions as shown in an idealized system of ethnobiological classification as proposed by Berlin et al. (1974: 26).

often a single *species* (see discussion below). Generic taxa are typically understood as sets of living organisms that reproduce after their own kind, the traditional biological species concept of academic biology (Mayr 1957). Generic taxa are structurally basic. That is, they constitute the foundation on which is built the elaborated taxonomic hierarchy.

Between the ranks of *kingdom* and *generic* occur taxa of the *life-form* rank. Life-form taxa are few in number, typically less than ten, and include the majority of folk generics. For example, in English *bird* designates a life-form category that includes hawk, robin, sparrow, and all other avian species.

In any folkbiological taxonomy, a few generic taxa are found to be either *ambiguous* with respect to a life-form assignment or *unaffiliated* with any life form. Ambiguity may result from “fuzziness” in the boundaries recognized for categories, such as between tree and bush in English. Unaffiliated generic taxa may be considered of such extraordinary cultural significance or so morphologically different from other plants as to preclude incorporation as a “kind of” something else. Thus, maize (*Zea mays*) for many Mexican Indians is not a “kind of grass” but rather maize, pure and simple. English speakers do not consider a cactus to be either a tree or a bush but, rather, just a cactus, and therefore leave it unaffiliated. As a consequence, taxa of a given rank, such as, folk generic, may be found at different taxonomic *levels*. Such levels are defined by the number of nodes between a taxon and the unique beginner, as is illustrated in Figure 19.2 above.

Brown (1984a) presents cross-language evidence that some plant and animal life forms are given names by languages in relatively invariant orders, analogous to the lexical encoding sequence for basic color terms found universally for languages described by Berlin and Kay (1969). For example, languages universally tend to name life-form categories comparable in membership to, but not always exactly the same as, English bird, fish, and snake, before they assign labels to categories dubbed by Brown as mammal and wug (*worm + bug*). The latter two frequently named animal life forms respectively encompass all big creatures that are not birds, fish, and snakes, and all little creatures that are not birds, fish, and snakes, that is, all large (mammal) and small (wug) residual animals. Thus, after the naming of bird, fish, and snake, all three of which are robustly perceptually based categories, the remaining creatures are conceptualized in terms of binary opposition based on size (big/little) and named as contrasting groups of residual creatures. The validity of life-form encoding sequences has been questioned on the grounds that all life forms do not demonstrate the same common logical or perceptual basis, and that they may be impossible to distinguish from large, polytypic generics (Hunn 1982; Randall and Hunn 1984). Brown (1984b) vigorously challenges the latter point, but agrees with the former. For example, it is clear to him now, as it was decades ago (Brown 1984a: 107–113), that bird, fish, and snake are more grounded in perceptual reality than are mammal and wug. However, recognition of the ontological status of such categories in no manner invalidates the empirical finding that the naming of bird, fish, and snake typically precedes the naming of mammal and wug in most of the world’s languages.

While life-form categories are always *polytypic*, that is, always immediately include at least two named taxa (ordinarily substantially more than two), folk generic taxa may be either *monotypic* or *polytypic*. If monotypic, the category includes just one type. For example, the generic category Coyote includes only the single species *Canis latrans*. Polytypic folk generics include two or more *folk-specific taxa*, the next rank below the generic in Berlin’s scheme (see Fig. 19.2). White Oak and Black Oak are two folk specifics included in the English folk generic oak.

Berlin argues that folk-specific taxa are typically named through use of secondary lexemes such as *white oak* and *cutthroat trout*. However, some specific taxa are named with

primary lexemes, as is often the case with *prototypical* folk specifics, that is, the most typical or best known species of a folk genus. Ultimately, a taxon is judged as folk specific by virtue of the fact that it is *immediately included* in a folk generic.

The statistical distribution of folk specifics exhibits a pattern known as the “Willis distribution” (Geoghegan 1976). Most generic taxa are monotypic, while the number of specific subdivisions of polytypic generics tails off along an inverse logarithmic curve. In traditional local systems, very large polytypic generics—those that include more than three or four specifics—are typically cultivated plants or domestic animals (Berlin 1992: 131).

Berlin defines an additional rank below the folk specific, that is, the *folk varietal* (see Fig. 19.2), which is nothing more than a structural replication of the folk specific. For example, in California there are several kinds of Live Oak (folk-specific taxon) such as the varietal taxa, Coast Live Oak and the Interior Live Oak. Typically, only a very few folk specifics will themselves be polytypic, including two or more folk varieties. Such cases are typically rare and usually limited to highly valued cultivars. Folk-varietal names are characteristically binomial or even multinomial, unless abbreviated, for example, Western Diamond-backed Rattlesnakes and Eastern Diamond-backed Rattlesnakes truncated respectively as Western Diamondback and Eastern Diamondback.

The psychological properties of folk-specific and folk-varietal taxa are not always clear cut. As a rule, specific and varietal taxa will be logically *monothetic*, that is, defined with respect to a simple feature contrast, such as color (black or white) or size (big or little). Such taxa will lack a distinctive *gestalt*, that is, a characteristic perceptual pattern. A “red rose,” for example, is simply a rose that is red, and is not a particular variety of a rose for which a distinct gestalt can develop for people. However, folk-specific and even varietal taxa—defined structurally and nomenclaturally—may exhibit a range of logical and perceptual properties. Many folk-specific taxa correspond closely with biological species and are distinguished from congeners by a multiplicity of properties. For example, King or Chinook Salmon (*Onchorhynchus tshawytscha*) differ from Silver or Coho Salmon (*O. kisutch*) and from Dog or Chum Salmon (*O. keta*) in many details of shape, color, habitat, and life history, not to mention taste. Each is considered a distinct species not only by scientists but also by commercial and sport fishermen. In English we use binomial names, which are “secondary lexemes” in Berlin’s typology, though Columbia River Indians give each species a distinct folk generic name (Hunn 1980). Such cases exhibit all the logical and perceptual criteria considered definitive of the folk genus. This suggests that Berlin’s universal ranks do not represent fundamental cognitive contrasts. Hunn (1976) has proposed a “perceptual distance model” as an alternative to Berlin’s taxonomic structural model to better account for the underlying psychological processes at play in folkbiological classification. This alternative accounts for the basic properties of taxonomic hierarchies but also explains phenomena that violate expectations of the taxonomic model.

Finally, Berlin defines an *intermediate* taxonomic rank between the folk generic and the life form. He notes that intermediate taxa are often covert (1992: 33–34; and see discussion above). Intermediate “taxa” sometimes are poorly delineated, representing not categorization properly speaking but rather the recognition of *taxonomic chains* generated from perceived similarities (Hunn 1975a; Hunn and French 1984), or simply *ad hoc* groupings (Brown 1974). For example, dolphins and whales for most English speakers “go together,” despite their contrasting names. However, the Orca or Killer Whale may be seen as a link in a chain of resemblance that connects the smaller, toothed “Cetaceans” (to use the technical term), that is, the dolphins and porpoises, with the larger, mostly filter-feeding great whales.

Berlin’s taxonomic proposal is imperfect but provides an essential common framework for comparative analysis. Future refinements might incorporate what Hunn terms *generic elevation* to account for taxonomic elaborations in treating domesticated species of special

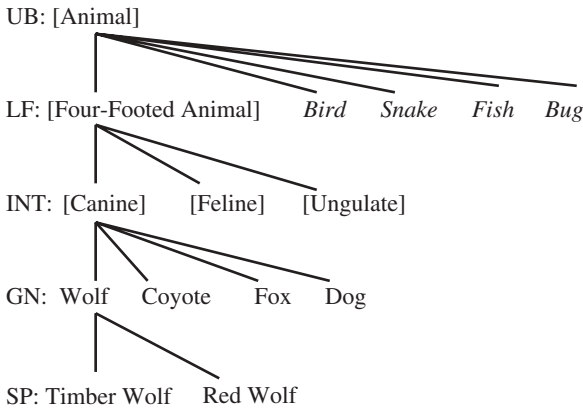


Figure 19.3 Standard taxonomic representation following Berlin (1992).

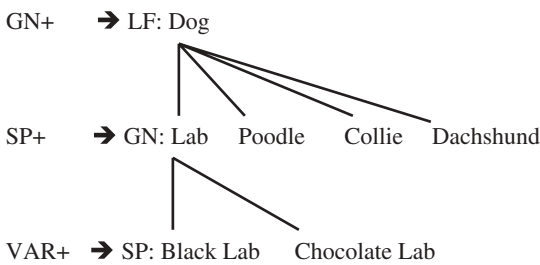


Figure 19.4 Elevation of dog to quasi-life-form status.

cultural salience in Western society (see Figs 19.3 and 19.4). In English, dog is a folk generic, although corresponding to a single biological species, *Canis familiaris*. Yet dogs have been bred to such a degree that variation within this single species mimics that within an entire life form. English nomenclature reflects this. The major breeds are named with primary lexemes, for example, *poodle*, *collie*, *retriever*, *great dane*, *dachshund*, and so on, as if they were folk generic taxa. These major breeds may then be further differentiated by means of binomial terms, such as, *toy poodle*, *border collie*, and *Labrador retriever*. Finally, Labrador retrievers may be called more simply *labs* and discriminated yet more finely as *black labs*, *chocolate labs*, and so on. These elaborations suggest that dog is first of all a folk generic but may also be “elevated” to quasi-life-form status. Consequently, major dog breeds are elevated to generic status (as the nomenclature suggests), some of which are polytypic, including “specifics” and “varietals” in turn. An alternative to this proposal is discussed by Brown (1987) wherein categories relating to major canine breeds would be recognized as *folk subgenerics*, that is, generic taxa that are immediately included in generic taxa (in this example, in a generic class labeled by *dog*). However this interesting phenomenon may be described, the nomenclatural elaborations in naming dogs, cats, horses, roses, and other highly salient species typical of Western cultures show that patterns recognized by Berlin still in general hold firm.

Differences in Folk Classification and Nomenclature Across Societal Types

In small-scale traditional societies, “mutts only” is generally the rule for dogs. Yet extensive classificatory elaboration may be found in traditional societies for biological domains that

receive little embellishment in the folk classification of people of nation-states. For example, the Aguaruna Jívaro of Amazonian Peru recognize and name more than 60 varieties of manioc (*Manihot esculenta*) (Boster 1985). In contrast, how many speakers of American English can name but a single variety of this cultivar?

Agriculturalists use binomial labels, such as English *white oak* and *cutthroat trout*, substantially more frequently than do foragers. Collective generic terms such as *oak* and *trout* are common in vocabularies of many agrarians, but rare in those of hunter-gatherers for whom each species is more likely to be granted its own generic name. These societal differences were first recognized independently by Hunn and French (1984) and Brown (1985). Hunn and French (1984) report a dearth of binomial labels in the folkbiological classification of speakers of Sahaptin, a hunter-gatherer group of the Pacific Plateau (North America), and point out that this is in sharp contrast to the generous use of binomials in the classification systems of traditional agriculturalists (such as the Tzeltal of Mexico and the Hanunóo of the Philippines).

Brown (1985) is the first to attempt to quantify this difference by using large comparative samples. In his study, two language samples are used, one for botanical classification involving 36 globally distributed languages, and one for zoological classification involving 11 globally distributed languages. For Brown's botanical sample, 20 of the 36 languages pertain to non-farmers and the remaining 16 to farmers. For the zoological sample, 6 of the 11 languages pertain to non-farmers and the remaining 5 to farmers. Only 3.6% of plant classes and 7.6% of animal classes in the vocabularies of non-farmers are binomially labeled. In striking contrast, for farmers the comparable figures were 35% of all plant names and 31.6% of all animal names. These findings indicate that binomial labels are common in the folkbiological classifications of farmers, but rare in those of hunter-gatherers.

Brown (2001) considers possible explanations for the development of generic terms and binomial labels with the shift from a hunting-gathering way of life to one involving full reliance on agriculture. He notes an early Hunn and French (1984: 86–89) review of several possibilities. The explanation embraced by Hunn and French (1984) and originally by Brown (1985) as well, relates to the number of plant and animal classes pertaining to a folk system of biological classification. Data first assembled by Brown (1985) indicate that the size of such systems is positively correlated with the mode of subsistence: hunter-gatherers tend to have systems with considerably fewer biological classes than those of farmers. Also, the original data seem to indicate that the use of binomial labels is positively correlated with system size: the larger the system, the more binomial labels used. To explain this correlation, both Hunn and French (1984) and Brown (1985) note that binomial names may be especially useful in helping humans to store and recall large amounts of folkbiological knowledge. If so, this helps to explain the increase in binomial percentage with augmentation of the size of a system of biological classification. A problem with this explanation is that it is not clearly the case that the ethnobiological inventories of hunter-gatherers are always substantially smaller than those of farmers. Indeed, this was pointed out early by Headland (1985).

Brown (2010b) more recently favors an explanation offered by Berlin that emphasizes the role of domestication (1992: 286). With the development of farming, cultivars may have been the initial recipients of binomial names, a naming strategy that is generalized to wild relatives of cultivated plants and animals, then to closely similar sets of organisms both domesticated and wild. Another explanation offered by Eugene Anderson (pers. commun.) is that when societies become larger and more complex with the development of agriculture, people tend to move out of their smaller original habitats and encounter very similar, but nonetheless not the same plants and animals in new environments, this prompting them to employ

primary lexemes for monotypic generic classes as head terms in binomial names for newly encountered similar species.

Comparing Folk with Linnaean (Scientific) Classification

Linguistic ethnobiology aspires to be a comparative science. Berlin's universal principles focus on cross-language patterns of classification and nomenclature which, according to Atran (1990), have been a primary source of inspiration in the development of the Linnaean classification of systematic biology. If both scientific taxonomists and folk classifiers view the biological world in the same way, then a 1:1 correspondence of basic folk taxa with scientific species is perhaps anticipated. Some investigators report a very high percentage of basic folk taxa in 1:1 correspondence with scientific species. Diamond (1966), for example, indicates that 85% of 110 Fore (Papua New Guinea) basic bird taxa correspond perfectly with locally resident bird species. However, Berlin reported that 61% of Tzeltal plant generics correspond 1:1 to scientific species, while Hunn tallied just 44% of animal generics in perfect correspondence (Hunn 1977: 82). Invertebrates weighed this statistic down, since many of these correspond closely to scientific taxa, but to genera, families, or orders rather than to species. Hunn (1975b) devised a more appropriate if somewhat clumsy index of this correspondence, which increases the agreement rate from just 44% to 92%.

The failure to achieve 1:1 correspondence may be due to a failure of the scientific taxonomist rather than that of the folkbiologist. For example, Columbia Plateau Indian elders distinguish *mamīn* from *sasamit'a*, both of which are considered to belong to a single Linnaean plant species, according to the definitive *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1973: 329). However, the elders consider *mamīn* roots to be a favorite food, while those of *sasamit'a* are considered to be of interest only to "groundhogs." More recent laboratory analysis proved the elders were correct; the Indian names refer to two quite distinct species (Hunn and French 1981; Schlessman 1980).

In many cases correspondence is close but not perfect. These may be tallied as either *over-differentiation* or *under-differentiation* (Berlin et al. 1973). In the former instance, folk-taxonomists *split* a scientific species; in the latter they *lump* two or more such species. Over-differentiation is primarily encountered with cultivated varieties for which we often lack any corresponding scientific names, although such cultivated varieties may well be genetically distinct. One must be careful here not to misconstrue nomenclatural distinction of sex and age as over-differentiation. In English we may speak of a cow and a bull but, except for the collective noun *cattle*, we have no ready term for the species *Bos taurus*. Yet can there be any doubt that most adult Anglophones know perfectly well that we have but a single species here?

Under-differentiation may range from lumping together two closely allied species of a single genus to the use of catch-all residual categories such as the American English "bug." The Koyukon of the Alaskan interior are intimately familiar with their local bird life yet fail to distinguish Greater from Lesser Scaup, and Common from Hoary Redpolls (Nelson 1983: 269–270). These species pairs are notoriously difficult to distinguish. By contrast, Indigenous farming communities in the tropics often dismiss the multitude of migratory warblers and flycatchers in very general terms. *Yaj* in Yucatec Maya refers to "small dull-colored flycatchers, a catchall term with vague boundaries . . ." that might include over a dozen species of several genera of the tyrant flycatcher family (Anderson and Medina Tzuc 2005: 173). When Hunn pestered his Sahaptin teachers for the names of various wild flowers

blanketing the spring slopes of the Columbia Basin, he was told that they were *awtya ay latit*, that is, “just flowers” (Hunn and Selam 1990: 198–200). Patterns of over- and under-differentiation provide evidence for cultural focus. Elaboration of vocabulary as a rule is motivated by utilitarian biases, not limited to what is edible but including as well species of medicinal, technological, aesthetic, spiritual, and ecological value (Hunn 1982).

Hunn’s (1999) Scientific Species Recognition Ratio (SSRR) calculates the degree of precision of the entire folk system of a human group in granting recognition to local biodiversity, measured in terms of local species richness as recognized by local versus Linnaean systems. If there were 100 Linnaean species of a particular class of organism known to occur within the experiential range of a community and that community were to recognize 65 corresponding basic categories, then the ratio in question would be 0.65. This index allows comparisons between basic categories such as plants versus animals, birds versus mammals, large versus small organisms, and aquatic versus terrestrial species within a cultural system, as well as cross-cultural comparisons, calibrated to the specific biogeographic reality. One positive result of using this index is the not entirely surprising finding that smaller organisms are recognized in folk systems with less precision than are larger organisms.

REFERENCES

- ANDERSON EN, MEDINA TZUC F. *Animals and the Maya in southeast Mexico*. Tucson: University of Arizona Press; 2005.
- ATLAN S. *Cognitive foundations of natural history*. London: Cambridge University Press; 1990.
- BERLIN B. *Ethnobiological classification: principles of categorization of plants and animals in traditional societies*. Princeton (NJ): Princeton University Press; 1992.
- BERLIN B, KAY P. *Basic color terms: their universality and evolution*. Berkeley: University of California Press; 1969.
- BERLIN B, BREEDLOVE DE, LAUGHLIN RM, RAVEN PH. *Cultural significance and lexical retention in Tzeltal-Tzotzil ethnobotany*. In: EDMONSON MS, editor. *Meaning in Mayan languages*. The Hague: Mouton; 1973. p 143–164.
- BERLIN B, BREEDLOVE DE, RAVEN PH. *Principles of Tzeltal plant classification: an introduction to the botanical ethnography of a Mayan-speaking people of Highland Chiapas*. New York: Academic Press; 1974.
- BOSTER JS. “Requiem for the omniscient informant”: or, there’s life in the old girl yet. In: DOUGHERTY JWD, editor. *Directions in cognitive anthropology*. Urbana: University of Illinois Press; 1985. p 177–198.
- BROWN CH. *Unique beginners and covert categories in folk biological taxonomies*. *Amer Anthropol* 1974; 76:325–327.
- BROWN CH. *Language and living things: uniformities in folk classification and naming*. New Brunswick (NJ): Rutgers University Press; 1984a.
- BROWN CH. *Life-forms from the perspective of “language and living things”: some doubts about the doubts*. *Amer Ethnol* 1984b;11:589–593.
- BROWN CH. *Mode of subsistence and folk biological taxonomy*. *Curr Anthropol* 1985;26:43–64.
- BROWN CH. *The folk sub-genus: a new ethnobiological rank*. *J Ethnobiol* 1987;7:181–192.
- BROWN CH. *Linguistic ethnobiology: Amerindian oak nomenclature*. In: FORD I, editor. *Ethnobiology at the millennium: past promise and future prospects*. Ann Arbor: University of Michigan Museum of Anthropology; 2001. p 111–147.
- BROWN CH. *Prehistoric chronology of the common bean in the New World: the linguistic evidence*. *Amer Anthropol* 2006a;108:507–516.
- BROWN CH. *Glottochronology and the chronology of maize in the Americas*. In: STALLER JE, TYKOT RH, BENZ BF, editors. *Histories of maize: multidisciplinary approaches to the prehistory, biogeography, domestication, and evolution of maize*. San Diego (CA): Elsevier; 2006b. p 647–663.
- BROWN CH. *Development of agriculture in prehistoric Mesoamerica: the linguistic evidence*. In: STALLER JE, CARRASCO MD, editors. *Pre-Columbian foodways: interdisciplinary approaches to food, culture, and markets in Mesoamerica*. New York: Springer Publishers; 2010. p 71–107.
- BROWN CH. *Ethnobiology and the hunter-gatherer/food-producer divide: how hunter-gatherers differ from farmers in folk biological classification*. In: GÜLDEMANN T, McCONNELL P, RHODES RA, editors. *The languages of hunter-gatherers: global and historical perspectives*. Cambridge: Cambridge University Press; forthcoming.
- CONKLIN HC. *Lexicographic treatment of folk taxonomies*. In: HOUSEHOLDER FW, SAPORTA S, editors. *Problems in lexicography*. Bloomington: Indiana University Press; 1962.
- DIAMOND JM. *Zoological classification system of a primitive people*. *Science* 1966;151:1102–1104.

- GEOGHEGAN WH. Polytypy in ethnobiological classification. *Am Ethnol* 1976;3:469–480.
- HAYS TE. An empirical method for the identification of covert categories in ethnobiology. *Am Ethnol* 1974;3:489–507.
- HEADLAND TN. Comment on Brown (1985). *Curr Anthropol* 1985;26:57–58.
- HITCHCOCK CL, CRONQUIST A. *Flora of the Pacific Northwest: an illustrated manual*. Seattle: University of Washington Press; 1973.
- HUNN ES. Cognitive processes in folk-ornithology: the identification of gulls. Berkeley: Language Behavior Research Laboratory, University of California; 1975a.
- HUNN ES. A measure of the degree of correspondence of folk to scientific biological classification. *Am Ethnol* 1975b;2:309–327.
- HUNN ES. Toward a perceptual model of folk biological classification. *Amer Ethnol* 1976;3:508–524.
- HUNN ES. Tzeltal folk zoology: the classification of discontinuities in nature. New York: Academic Press; 1977.
- HUNN ES. Sahaptin fish classification. *Northwest Anthropol Res Notes* 1980;14:1–19.
- HUNN ES. The utilitarian factor in folk biological classification. *Amer Anthropol* 1982;84:830–847.
- HUNN ES. Place-names, population density, and the magic number 500. *Curr Anthropol* 1994;35(1):81–85.
- HUNN ES. Size as limiting the recognition of biodiversity in folkbiological classifications: one of four factors governing the cultural recognition of biological taxa. In: MEDIN DL, ATRAN S, editors. *Folkbiology*. Cambridge (MA): MIT Press; 1999. p 47–69.
- HUNN ES, FRENCH DH. *Lomatium: a key resource for Columbia Plateau subsistence*. Northwest Sci 1981; 55:87–94.
- HUNN ES, FRENCH DH. Alternatives to taxonomic hierarchy: the Sahaptin case. *J Ethnobiol* 1984;3:73–92.
- HUNN ES, with James Selam and family. *Nch'i-Wána "The Big River": Mid-Columbia Indians and their land*. Seattle: University of Washington Press; 1990.
- HUNN ES. *A Zapotec natural history: trees, herbs, and flowers, birds, beasts, and bugs in the life of San Juan Gbëë*, with CD Rom. Tucson: University of Arizona Press; 2008.
- KAY P. Taxonomy and semantic contrast. *Language* 1971;68:866–887.
- LÉVI-STRAUSS C. *The savage mind*. London: Weidenfeld and Nicolson; 1966.
- MAYR E. Species concepts and definitions. In: MAYR, editor. *The species problem*. Washington (DC): American Association for the Advancement of Science; 1957.
- NELSON RK. *Make prayers to the raven: a Koyukon view of the northern Forest*. Chicago (IL): University of Chicago Press; 1983.
- RANDALL RA, HUNN ES. Do life-forms evolve or do uses for life? Some doubts about Brown's universals hypotheses. *Amer Ethnol* 1984;11:329–349.
- SAUSSURE F DE. Course in general linguistics. In: BALLY C, SECHEHAYE A, editors (trans. HARRIS R). La Salle (IL): Open Court; 1983.
- SCHLESSMAN MA. *Systematics of the tuberous species of Lomatium* [PhD dissertation]. Seattle: University of Washington; 1980.

Chapter 20

Cognitive Studies in Ethnobiology: What Can We Learn About the Mind as Well as Human Environmental Interaction?

NORBERT ROSS

Vanderbilt University, Nashville, TN

CAISSA REVILLA-MINAYA

Vanderbilt University, Nashville, TN

CATEGORIZATION AND REASONING	337
CATEGORIZATION: EXPERTISE AND CULTURE	338
REASONING: EXPERTISE AND CULTURE	341
REASONING, CULTURE AND BEHAVIOR	343
ACQUISITION OF FOLKBIOLOGICAL MODELS: INNATE MODELS AND CULTURAL KNOWLEDGE	345
WHAT IS CULTURE AND HOW DO WE STUDY IT?	346
CONCLUSION	347
REFERENCES	347

As *cognitive scientists* we are interested in folkbiology as a domain that allows us to explore the developing mind in phylogenetic and ontogenetic terms. Everyone has some exposure to the biological world; hence comparative research is feasible. Throughout most of human history, our species engaged with the biological world for survival, so biology might be one domain where evolutionary biases in our cognitive apparatus—if they indeed exist—are most salient. As *anthropologists* we are interested in folkbiology for two reasons, which

connect to the interests of the cognitive scientists. We ask how human thought about the environment relates to the ways our species acts upon the environment. Research in this area relates cognitive work with behavioral studies of resource management and conflict over resources (Atran et al. 1999, 2002; Medin et al. 2006a, 2007; Ross 2001, 2002a; Ross et al. 2007). Another inquiry explores the acquisition, transmission, and transformation of knowledge, exploring children's learning, transmission, and transformation of knowledge across cultures and generations, and loss of knowledge (Atran and Medin 2008; Atran et al. 2004; Ross 2002a,b; Ross et al. 2003; Stross 1970; Waxman et al. 2007; Wolff et al. 1999; Zarger 2002a,b; Zarger and Stepp 2004; Zent 2001). These studies link the two disciplines involved in the cognitive research of folkbiology, and relate the work to environmental education. They connect folkbiology with theoretical questions relating to culture and cultural processes (Atran et al. 2005; Ross 2004; Sperber 1996).

We address important aspects in culture and cognition by introducing culture into the study of the mind and vice versa. Important and relevant literature is spread over a wide array of journals that very likely do not represent the staple reading of any one researcher; for example: *Journal of Ethnobiology*; *Economic Botany*; *Ethnobiology and Ethnomedicine*; *Current Anthropology*; *Journal of the Royal Anthropological Society*; *Cognition*; *Child Development*; *Psychological Review*; and *Human Biology*. This provides a challenge for an integrative approach, as different theoretical and methodological approaches and achievements are often ignored across the two disciplines (Ross and Medin, in press).

In anthropology the initial focus has been on the *content* of folkbiological knowledge—the documentation of intricate knowledge systems as held by Indigenous people (Berlin et al. 1974; Conklin 1954, 1962; Frake 1961, 1962). The early work in this domain by Berlin et al. (1973, 1974) proved path-breaking in several regards. First, it showed the necessity of interdisciplinary research by incorporating botanists and zoologists into large-scale research projects. Second, the research set a high standard in terms of systematic long-term data collection in the field. The project showed that folk experts often hold biological knowledge comparable to—if not exceeding—bioscientific knowledge.

Similar projects followed (Balée 2002; Messer 1991; Shepard et al. 2004; Zent and Zent 2002), yet—partially driven by criticism in anthropology—the focus of interest expanded from documenting solely *group knowledge* to assessing the *distribution of knowledge within groups* (Boster 1987; La Torre Cuadros and Ross 2003; Ross 2002a,b, 2004). Studying knowledge distribution was enhanced by the emerging use of microcomputers and the development of new statistical models, such as the Cultural Consensus Model (Romney et al. 1986), which we will describe in Box 20.1. These studies involved relatively little attention to the process of thinking. *What we think* was very often studied independently of *how thinking actually takes place* (D'Andrade 1981; for an exception see Randall 1976, 1987). In recent years it has become clear that *knowledge content* cannot be separated from the *processing of information/knowledge*.

Representational systems are a case in point. Culture provides organized systems of knowledge (D'Andrade 1981)—or cognitive tools (Norman 1993)—with specific properties that affect information processing. These “representational effects” are well documented for navigation (Hutchins 1983, 1995) and for numerical cognition (e.g., Chrisomalis 2004; Miller et al. 1995; Nickerson 1988).

We attend to production, distribution, transmission, and transformation of this knowledge in specific socio-cultural contexts. The implications go beyond cognitive science, addressing some of the major critiques of anthropological research, such as treating idea systems as units without history.

BOX 20.1 *Cultural Consensus and Residual Analysis*

We do not consider culture to be a limited set of practices and beliefs, but rather the distribution of ideas in a particular group of people. Our interest is precisely to determine the patterns reflected in these distributions and to explain the processes that may be behind such patterns. We use the Cultural Consensus Model (CCM) to measure the existence of a consensus among groups of participants and the extent to which an individual participates in this consensus or agrees with the overall model (Nakao and Romney 1984; Romney et al. 1986; Ross 2004). The CCM is a factor-analytical model that explores the observed participant agreement matrix in terms of variance explained by the first factor. Consensus can be assumed if (1) the ratio of first and second factor eigenvalues is greater than 3, (2) the first factor explains a large amount of variance, and (3) all participants' first factor loadings are high and positive.

If consensus exists we are formally justified (1) to aggregate individual responses to a modal response for comparative purposes and (2) to explore the existence of subgroups of informants, based on patterns of *residual agreement*—

agreement not explained by two individuals' participation in the overall consensus (Nakao and Romney 1984; Romney et al. 1986; Ross 2004).

Residual agreement is calculated by subtracting *predicted agreement* (the product of two participants' individual agreement with the consensual model) from *observed agreement*. The resulting residual agreement matrix can be explored with respect to specific group differences (*is within-group residual agreement higher than between-group residual agreement?*). Distribution of residual agreement does not have to be symmetrical, that is, members of one group might agree more with their peers than with members of the other group but not vice versa (see Medin et al. 2006a for an example). In this case, the first group holds a sub-model not shared by the members of the second group, which does not have a group-specific sub-model. Residual analysis also allows us to explore whether specific personal attributes predict higher residual agreement. Combined, these analyses provide powerful tools to explore the structure and distribution of domain specific knowledge.

Researchers in folkbiology have been on the forefront of integrating diverse theories and methods. Traditional ethnographic methods merge with experimental field methods and specific analytical techniques, such as the cultural consensus model, the analysis of residual agreement, and social network analysis.

CATEGORIZATION AND REASONING

The assumption of a universal folkbiology domain might seem challenged by linguistic data. For example, most Maya languages do not have words (though they may have grammatical particles) for “living kinds,” “animals,” or “plants.” Instead, initial linguistic encoding based on specific words happens at the life-form level (“tree”/“mammal”). This, however, does not mean that *animals* and *plants* are not recognized as conceptual categories that share important features, among others “being alive,” “being able to die,” or “grow.” Many, perhaps most, Indigenous languages share this. Some languages (including Yucatec Maya) mark “plant” and “animal” with specific prefixes or counters.

The biggest argument in favor of a shared domain of folkbiology comes from research into categorization. People appear to classify plants and animals in similar ways, suggesting that our cognitive apparatus evolved in ways to detect the “lines and cracks” in the evolution of species (Atran 1990, 1998; Berlin 1992). In this account, folkbiology represents a domain

of human cognition that specifically evolved to reason about and to interact with the biological world. This would make folkbiology an innate cognitive faculty, like language (according to some theories), naïve physics, and naïve psychology. Studies with infants indicate the existence of innate and quickly acquired skeletal principles specific to the above-mentioned domains. Some researchers hold that, rather than being an independent domain, biological understandings develop out of children's understanding of folkpsychology: the way humans reason about other humans. In this account, young children initially reason about animals and plants based on their knowledge about humans and, only after going through a conceptual change (akin to Kuhn's paradigm shift), do they develop a true folkbiology (Carey 1985). We will come back to this discussion, as it bears upon some crucial issues of child development as well as the role of cultural and expertise differences.

Interest in taxonomic structures came in part from linguistic evidence showing the existence of similar taxonomies around the globe (Berlin 1992). Experimental sorting methods (see Ross 2004 for some examples) supported and extended the linguistic evidence to a strong body of data describing some core principles of taxonomic structures.

The interest in taxonomic structures paralleled the cognitive science interests in categorization and categories as the *building blocks of thought* (Smith and Medin 1981). Categories not only allow for efficient thought and communication by lumping elements together (see D'Andrade 1995), but also—and maybe more importantly—categories and categorical structures provide the bases for reasoning processes.

Criticism of anthropological accounts of folk-taxonomies proposed that the taxonomic structures do not represent Indigenous forms of thought, but instead are the outcome of the structuring produced by the methods applied (Ellen 1986). To counter this claim one needs to show that the elicited taxonomic structures are actually used by our informants when reasoning about the species involved. If this is the case, we can assume that the elicited structures represent some aspect of how humans organize knowledge. Evidence now exists that this is the case. Arguing against a utilitarian perspective, that is, that Indigenous people know the world only to the extent that they need it (Diamond 1972), Berlin proposes a view that accounts for the emergence of systems of biological classifications as the result of “human beings’ inescapable and largely unconscious appreciation of the inherent structure of biological reality” (Berlin 1992: 8). Several questions immediately emerge for further research. First, how do folk-taxonomies of living kinds compare to scientific taxonomies and to one another? Second, are folk-taxonomies employed in reasoning strategies (and if so, how)? Third, are there specific levels in the taxonomies that are more basic, for example, deemed as more relevant for inductive reasoning? Fourth, how does categorization and reasoning hold up in a context of cross-cultural and cross-expertise research?

Categorization: Expertise and Culture

We have comparative data from European-American fish experts and novices from the southeast United States (east Florida, west Florida, Texas, and North Carolina) (Boster and Johnson 1989); experts and novices on songbirds and tropical freshwater fish (Johnson and Mervis 1998); freshwater fish experts and novices among Menominee and Euro-Americans in Wisconsin (Medin et al. 2002, 2006); bird experts and novices in Chicago; Itza' Maya of Guatemala (Bailenson et al. 2002); Itza' Maya and University of Michigan students on local mammals (López et al. 1997), and different kinds of tree experts in the greater Chicago area (Medin et al. 1997). In addition we have data on Tzeltal Maya farmers and their plant classification (Berlin et al. 1974), as well as Aguaruna bird classifications

(Boster et al. 1986) and how they compare with those of University of Kentucky students (Boster 1987; Boster and D'Andrade 1998).

Several points become clear from this body of work (see also Hunn and Brown, 2011): First, folk-taxonomies are generally similar across the globe and tend to agree strongly with scientific classifications. On average, the correlations between folk-taxonomies and scientific classifications range around $r = 0.6$ (see Ross and Tidwell 2010). This lends support to the above-mentioned suggestions that folk classification systems might indeed have developed as the interplay of cognitive factors (including perception) with the biological world, rather than one or the other.¹ Second, in-group and cross-group agreement are very often coupled with systematic within-group differences. Two candidates to account for group differences have been tested: cultural frameworks and expertise, both of which have been shown to impact categorization. Boster and Johnson (1989) have shown that the move from novice to expert is not just a move from not knowing to knowing, or from an incoherent to a more coherent model, but a difference in models *per se*. Experts tend to be aware of and pay attention to features not recognized or valued by non-experts.

Following the idea of different goal structures and related practices, Douglas Medin and his collaborators explored the categorization schemes of different kinds of tree experts in the wider Chicago area (Medin et al. 1997). Results indicate that both agreement and group-specific disagreement are largely explainable with respect to the needs and interests of the groups in question (Medin et al. 1997; Proffitt et al. 2000). Acknowledging expertise as multidimensional opened the space of exploring the role of cultural frameworks or epistemologies. Along these lines Medin and collaborators compared Menominee and Euro-American fish experts and novices in rural Wisconsin (Medin et al. 2002, 2006b). Given the setting, “novices” in these studies were rather knowledgeable when compared to college students—the usual suspects in comparative research. Everyone in the area had done at least some kind of fishing at one point in his/her life. Previous studies on categorization and reasoning suggested that experts would agree more with one another than with non-experts of their own group. On the other hand, non-experts in these studies were always college students, who differed from the experts not only in their lack of expertise, but also in factors such as age, education and incentive to participate (very often class credit).

Members of all four groups basically agreed with one another on the classification of local freshwater fish species. Experts and non-experts of each group agreed more with one another than with either the two expert or the two non-expert groups. Our data seemed to have tapped into culturally specific differences in the acquisition of expertise leading to differences in kinds of expertise. Data clearly establish the importance of cultural frameworks in the acquisition of folkbiological expertise in ways not captured by studies simply looking at levels of expertise.

An extension to the above-mentioned study with Menominee and Majority Culture fishing experts clarifies how specific cultural frameworks provide the ground for emerging differences among experts across cultures (see Medin et al. 2002, 2006b).

Combining the cultural consensus model with an analysis of residual agreement (see Box 20.1) we explored the folk-taxonomic models of the two expert groups for local freshwater fish (elicited in a card pile sort). We detected a cross-group consensus paired with

¹It is important to note that different dimensions of how people categorize their biological world are often interdependent. While people might attend to different dimensions, the outcome in terms of categorization of living kinds might be similar. For example, for Menominee fish experts (discussed below) we were able to identify ecological reasoning in their categorization of freshwater fish, entailing topics such as food chain and habitat. Both of these dimensions are clearly linked to the morphology of fish.

systematic asymmetric differences in residual agreement. Menominee experts hold a submodel not shared with Euro-Americans, but not vice versa. We aggregated the data for each group into a combined model, which was analyzed using multidimensional scaling. In order to represent the model of the Euro-American experts two dimensions were needed, correlating with the desirability of the fish and their size. For the Menominee data three dimensions were needed to achieve a fit for their sorting data. Two dimensions correlated with size and desirability and the third dimension—not found among Euro-Americans—correlated with what we termed an ecological dimension (for example, sorting by habitat).

Several months later we conducted a set of different but related tasks. First, we asked participants to describe fish–fish interactions for all possible pairs of 21 fish species (e.g., “Does A affect B or B affect A?”). In this task we asked about 420 potential relations within approximately 1.5 hours, that is, questions were paced at a fairly high speed.

We detected the same agreement pattern: cross-group consensus with only Menominee holding a systematic sub-model not shared by Euro-American experts. Menominee experts reported more relations overall and more reciprocal relations. Euro-American fishermen mainly reported interactions involving adult fish of the kind “a musky will eat a northern.” These relations were seen by Menominee too, but they added relations between fish of the whole life cycle as well as relations other than “A eats B.” Interestingly, there was only a small set of relations reported by Euro-American fish experts but not Menominee. These relations typically involved food-chain relations between predator and prey fish that are rarely—if at all—found in the same waters (a fact that was typically mentioned by Menominee participants).

On the surface it would seem that we were observing cultural difference in knowledge. However, from our ethnographic work we knew that the participating Euro-American experts were as knowledgeable as their Menominee counterparts with respect to fish habitats and it seemed implausible that Euro-American fish experts would have so little ecological knowledge.

In a follow-up experiment we had participants sort the fish according to different habitats (each fish could be assigned to several habitats). Members of both groups did *not* differ in their responses. Euro-American experts described fish as not sharing a habitat, for which in the previous task they had described a *big eats small* relationship. These data reinforced the notion that the cultural differences triggered in the former task did not represent a simple cultural difference with respect to existing ecological knowledge.

Provided the difference in knowledge organization, we theorized that the encountered cultural differences might represent differences in *access to knowledge* rather than *knowledge per se*. The sorting task suggests that Menominee fishermen make use of an ecological organization, which might facilitate answering questions about fish–fish interactions. On the other hand, if the Euro-American experts focus more on taxonomic relations it may take more time and effort to retrieve information about ecological relations. To test this idea we repeated the fish–fish interaction task several months later. However, this time we reduced the number of probes from 420 to 35 (focusing mainly on the probes for which differences were found in the initial task), allowing for approximately the same time. Results confirmed our hypothesis. When providing the participants with more time to answer the cultural differences disappear with the Euro-Americans answering like Menominee, who respond in ways similar to the fast paced task.

Experts of the two groups share base knowledge with respect to ecological relations and fish habitats. This should not be surprising given the fact that on average experts of the two groups fished for over 40 years. Arguably, knowing where fish can be found represents an important piece of information within fishing. This ecological knowledge, however, is not

equally accessible. We find systematic group differences (which one might be tempted to call cultural), yet these differences are not in knowledge *per se* but in access to this knowledge.

Cultural frameworks clearly play an important role with respect to categorization. The data further show that categorizations provide an organization of knowledge, which in turn affects the accessibility of kinds of specific knowledge.

This research illustrates the importance of a combination of formal quantitative tasks and ethnographic methods. Data show that it is important to pay attention to the nature of the interview and probes applied. Instead of attempting to find some diagnostic “gold standard” task that will reveal what people think or know, one needs coordinated and converging measures across a range of tasks.

REASONING: EXPERTISE AND CULTURE

Research in the cognitive sciences has shown that category structure provides the basis for reasoning strategies. These are considered heuristics for inference making (or decision making) when relevant information is incomplete. We will focus on two kinds of reasoning. The first is inductive reasoning about categories and their properties (what is often called category-based induction or CBI). Cultural research has shown the importance of framework theories and the organization of knowledge to this kind of reasoning. The second is causal reasoning, on which interesting cross-cultural research is also taking place (Burnett and Medin 2008).

Research on the use of categories in reasoning has been guided by theories of induction that suggest principles of induction, which may be universal. Probably the best known theory is the Osherson et al. (1990) similarity-coverage model. Three phenomena associated with the theory have received the most attention: *similarity*, *typicality* and *diversity*.

The *similarity* principle of induction describes the fact that two kinds seen as similar (closer related in terms of their taxonomic distance) are more likely to share a previously unknown (and invisible) property/characteristic, compared to two kinds that are taxonomically more distant. For example, informants usually judge mice and rats as more likely to share some unknown property than mice and penguins.

The *typicality* principle describes the fact that more typical members of a category are more likely to have features common to all the category members than less typical ones. For example, if informants are told that sparrows have some protein x inside them and that penguins have some protein y inside them, they judge that it is more likely that all birds have protein x than protein y.

Finally, the *diversity* principle describes the fact that individuals are usually more likely to ascribe a property to the whole category when told that two taxonomically distant category members share that property, than when told that two taxonomically similar category members share a property. A projection from mice and cows to all mammals is stronger than a projection from mice and rats to all mammals.

Studies with undergraduate students have shown stable effects with respect to these three phenomena. However, cross-cultural and cross-expertise studies reveal quite a different picture. Lopez et al. (1997) compared the categorization and CBI of University of Michigan students with Itza' Maya of the tropical rainforest of Guatemala with respect to local mammals (for each group a slightly different set of mammals was used). Specifically, they tested (1) whether members of the two groups use a similar taxonomic structure and (2) whether they use the three above-described principles when reasoning about categories and category members. The researchers found that Itza' Maya and Michigan undergraduates tended to sort

mammals into categories in more or less similar ways, relying on morphological characteristics and, in the case of the Itza', also on ecological factors such as habitat (e.g., otters are distinct as water creatures and bats are considered to be birds by Itza'). Both groups also showed similarity and typicality effects in reasoning. However, although undergraduates relied heavily on the diversity principles, Itza' Maya farmers showed *below chance* diversity reasoning.

The study has obvious limitations as it confounds cultural differences with differences in age, education, and so on and, most notably, in expertise with respect to living kinds. It does challenge, however, the universality of at least one of the principles, *diversity*. The challenge then is to understand why the two groups reasoned so differently when it came to taxonomic diversity.

Subsequent studies pinpoint domain knowledge and expertise (both the level and kind of expertise) as being one critical factor. Proffitt et al. (2000) studied inductive reasoning about trees among three different groups of Euro-American tree experts: landscapers, park maintenance workers, and taxonomists. Park workers, like the Itza' Maya tested by Lopez et al. (1997), responded reliably below chance with respect to the *diversity principle*. Another finding is of interest here: when judging which of two kinds of trees was more likely to share a disease with all other trees, the three different groups of Chicago-area tree experts preferred the tree with wider geographic distribution or greater intrinsic susceptibility to disease. In the former case, the idea is that trees with wider geographic distribution have greater potential to pass the disease to other species. In the latter case, the rationale is that the disease will spread more easily among trees of the susceptible species, which renders the disease widely distributed and more likely to spread to other species.

This sort of ecological and causal reasoning appears to be prominent among informants with considerable domain knowledge. In reasoning about diseases and enzymes (or "little things inside") in birds, both North American birdwatchers and Itza' Maya farmers in Guatemala tended to base their inferences on causal-ecological interactions, often focusing on geographic distribution (Bailenson et al. 2002). They tended to prefer, as premises, birds that were rich in known ecological associations with other birds.

Finally, we asked the Menominee and Euro-American fishermen of Wisconsin to reason about diseases and enzymes in fish. Most of the probes lent themselves to reasoning by typicality, similarity, or diversity. Overall, only 9% of inferences were based on similarity and/or taxonomic relationships. Fully 90% were based on transmission of the property through ecological interactions (Burnett et al. 2005).

One might conclude that only novices—lacking additional knowledge—use taxonomic similarity as a basis for reasoning. The story, however, is more complex. Knowledgeable reasoners almost surely prefer similarity-based strategies for properties that (they believe) participate in the similarity-based structure of the domain. Professional taxonomists did show diversity effects and employ taxonomic similarity most of the time (Proffitt et al. 2000). Similarity-based structure formed part of a causal framework. Knowledge provides flexibility: a variety of strategies that allow the reasoner to project different properties in different ways. Shafto and Coley (2005) found that, whereas fishermen projected diseases according to food chain relations among marine animals, they projected more abstract or ambiguous properties like an imaginary "property called sarca" among the same animals according to similarity or taxonomic relatedness, as did domain novices.

Even novices show this kind of flexibility when stimuli tap their knowledge. Using ecological contrasts that even undergraduates often know (e.g., jungle creatures versus desert creatures), Shafto, Coley, and Baldwin (Shafto et al. 2005) found that, against a background preference for reasoning according to taxonomic relatedness, undergraduates showed a

tendency to distinguish between properties. Participants with greater knowledge of the ecological groups were more likely to project diseases and toxins, but not abstract properties like “sarca,” among ecologically related animals.

Causal stories, however, are not uni-dimensional, but are often influenced by the foregrounding/backgrounding of specific kinds of information. One way to envision this is Barsalou’s argument of goal-derived categorization (1991), special ways of categorizing and reasoning that make certain kinds of knowledge more or less accessible. Cultural differences may often be saliency effects driven by framework theories or epistemological orientations that lead to different orientations with respect to some domain like folkbiology or the relation to human being of the rest of nature (Bang et al. 2007). We will come back to this point.

Categories might provide a privileged level for reasoning. The idea of *privileged* or *basic level* has been described by Rosch et al. (1976), for whom the *generic-species level* provided the basic level for reasoning. A psychologically preferred rank is inferred that maximizes the strength of any potential induction about relevant information. Rosch and colleagues (1975) were able to show that for artifacts the generic-species level (hammer, guitar) indeed constituted such a privileged level. However, for biological kinds the privileged level moved up to the life form. For example, instead of *maple* and *trout*, Rosch et al. (1976) found that *tree* and *fish* operated as basic-level categories for American college students. Thus, Rosch’s basic level for living kinds generally corresponds to the life-form level, which is superordinate to the generic-species level.

In contrast to Rosch and colleagues, Coley et al. (1999) found that folk-generic categories were inductively privileged for both Itza’ people and American undergraduate students, meaning that both Itza’ Maya and undergraduate students knew that inferences from and to folk-generic categories were consistently stronger than inferences from and to more general categories, and no weaker than inferences from and to more specific categories. Together with the data provided by Rosch, the data indicate that across-culture the generic species level is privileged in that people assume that it carries most information. Knowing about the importance of this level, however, is different from knowing the species involved. While the students studied by Rosch et al. knew about hammers and guitars, they were not familiar with maple trees and trout. Thus Coley et al. argue that it may be more accurate to characterize cultural differences in terms of the degree to which knowledge and experience correspond than as differences in the location of a single privileged level (Coley et al. 1999).

Reasoning, Culture and Behavior

We have identified two main reasons to study how and what people think about living kinds. First, category-based reasoning strategies might provide the building block for agreement pattern within (and to some extent across) populations, if underlying categories are shared. They allow us to address an important puzzle in anthropology: the stability of cultural models over time. Second, how people reason about the world has a direct impact how they act upon the world. We admit that much more data are needed to confirm these two points. Still, we think sufficient evidence exists so that further inquiries are warranted.

Experimental research can open new insights into important processes. For example, in the task with fish experts from Wisconsin we asked participants about 420 possible fish–fish interactions. In a related study we asked Itza’ Maya and two groups of migrants to the tropical rainforest of northern Guatemala about animal–plant interactions with respect to local

species (Atran et al. 2002). While we asked approximately 800 questions, we still only covered a fraction of species or species-interactions that actually take place in the tropical rainforest. It seems implausible to assume that people would learn these interactions either through direct observation or through a process of individual instruction and memorization.

How then does consensus emerge? Why do people agree with one another? These questions address an important issue of anthropological research: the emergence of agreement and consensus. They also address the stability of cultural models across generations. We have some evidence that CBI provides one mechanism through which people generate new (explicit) knowledge. In the already mentioned plant–animal interaction task we compared Itza’ Maya from two adult generations with respect to their responses. We found that young Itza’ Maya differed from their elders in some responses, yet still agreed with one another. This suggested that agreement can emerge in the absence of direct observation or teaching/learning. Exploring the cases where young Itza’ Maya agreed, but systematically differed from the responses of their elders, it became clear that young Itza’ Maya use certain animal–plant interactions and extend the responses to interactions with similar species involved. While on average this might provide a reasonable response (as similar animals might affect similar plants in similar ways) we have some cases where it doesn’t, opening a window into the underlying mechanics. For example, older Itza’ Maya make a difference between the way howler monkeys and spider monkeys affect the ramon tree. Howler monkeys help this tree species by swallowing the entire seed and dispersing it, whereas the spider monkeys hurt the tree by destroying the seed. Young Itza’ Maya, however, overextend similarity across the two monkey species and attribute the same effect on the ramon tree. Several other examples point in the same direction, supporting the idea that young Itza’ indeed use their (shared) taxonomy to generate agreed (albeit wrong) responses (see Atran et al. 2002). Thus taxonomic knowledge includes *tacit or implicit knowledge* that is available to produce new knowledge when needed. However, given expertise differences as well as changes in input conditions at the time of knowledge formation, systematic differences might be expected (see Ross 2001, 2002a,b for an example of intergenerational change among the Lacandon Maya of Chiapas).

Using the animal–plant interaction task described above, we were interested in linking *ecological centrality* with values and behavior. Ecological centrality of a plant was defined by the number of animals it helped. Plants that would help many animals were regarded as more central than plants that would help few or no animals. Several months after this task we conducted another set of experiments in which participants had to rank-order plants according to their importance. Three different scenarios were offered: (1) importance to Ego; (2) importance to God; and (3) importance to the *arux*, trickster-like forest spirits who protect the forest. Ego values and values according to God correlated strongly with the utilitarian value of plants (construction, medicinal, food etc.), as “God watches out for his children.” The rank-order for the *arux* correlated with the above-described ecological centrality index, indicating that in the eyes of the Itza’ the *arux* actually protect the species that are central to the survival and wellbeing of the animals—not the humans! This makes clear that once we factor out utilitarian values, dominant in a society where scarcity of resources is endemic, Itza’ Maya clearly have an agreed-upon notion of ecological centrality of species. Parallel to these cognitive studies we conducted tree counts in different plots of the three groups that participated in the overall study (Itza’ Maya, as well as two migrant groups) and found that ecological centrality predicted the frequency of trees found in these plots for Itza’ Maya only. This indicates that Itza’ Maya not only know about the centrality of specific species, but actually protect these species and change the environment accordingly (see Atran et al. 2002).

We could not come up with a similar behavioral measure for our study among Menominee and Euro-American fishermen. However, we were able to explore the role of stereotypes people hold about members of the other group, both with respect to fishermen (Medin et al. 2006b) and to hunters (Ross et al. 2007). Most of the stereotypes were held by Euro-American hunters and fishermen and directed against Menominee (although Menominee also hold some stereotypes about Euro-Americans). In this study we probed within-group variations in order to better understand more specific aspects of stereotyping. The Euro-Americans who differed most from Menominee experts' goals or ways of categorizing fish showed more stereotyping than their peers, who tended to agree more with Menominee on these matters. Initially, we thought that this might be an outcome of familiarity with individual Menominee, but social network data proved that this was not the case. Apparently, observations are interpreted and evaluated through the cultural lens of the observer. For example, a Euro-American hunter might see Menominee killing smaller bucks than he himself would shoot, given his focus on trophy hunting. This "bad behavior," taken together with the observation that there are fewer deer on the reservation (a fact that is due to the lower carrying capacity of forests in general), might lead him to interpret Menominee hunting behavior as detrimental to the deer population (see Ross et al. 2007). Clearly then, cognitive models inform human behavior, fueling an already existing conflict about natural resources (see Medin et al. 2006a).

Acquisition of Folkbiological Models: Innate Models and Cultural Knowledge

We have mentioned the work of Susan Carey, who ascribed the development of folkbiological thought to a later stage basically emerging as a conceptual change out of the presumably innate folkpsychology (Carey 1985). The core of her finding is based on an inductive reasoning task where children in her sample were more likely to ascribe attributes from humans to animals than vice versa. Carey took this asymmetry as an indication that young children (age < 10) use humans as a basis to reason about animals, for example, that folkpsychology provides the framework for a developing folkbiology. However, for anyone familiar with rural children around the world (including the USA), the urban children participants' ignorance of basic biological facts is remarkable. The participants were all urban children of Boston. We have discussed the role of expertise and the differences in categorization and reasoning between adult experts and novices. Such differences could influence child development. The trajectory described by Carey may describe only the development of novice children with little or no exposure to the natural world. Kayoko Inagaki (1990) has shown that kindergarten children (age < 5) raising goldfish, besides acquiring more factual knowledge about goldfish, also attained conceptual knowledge through which they could reasonably predict goldfish behavior more accurately than children who were not raising goldfish. Moreover, goldfish-raising children were able to predict reactions of unfamiliar aquatic animals, such as frogs, using their knowledge about goldfish as an analogy.

We conducted a study comparing both rural Euro-American and Menominee children from Wisconsin with children residing in Boston (Ross et al. 2003). Using essentially the same methods as Carey, we found two interesting results. First, rural children do not show the same human–animal asymmetry as described by Carey for the Boston children. As before, our Boston children show a remarkable lack of folkbiological knowledge—they were at chance on whether trout are alive or not. Second, Menominee and only they

showed clear examples of ecological reasoning (bee stings the bear, the bear eats honey) leading to inferences from one species to another. This finding is especially striking as it parallels our findings with respect to experts of the same two communities.

Knowledge elicited in our studies may be transmitted by explicit teaching, yet this is only one possibility. Bang et al. (2007) asked Menominee and Euro-American children and adults about the nature and frequency of their outdoor practices. They found that Euro-Americans were much more likely to engage in practices in which nature is backgrounded (e.g., playing baseball), and much less likely to engage in practices in which nature is foregrounded (e.g., berry picking). There is independent evidence that what we might call “psychological distance” affects cognitive processing in a variety of ways, including inferences and attributions (see Trope et al. 2007).

A related set of observations comes from Unsworth (Undated manuscript). She asked Euro-American and Menominee adults to describe the last encounter they had had with a deer. In addition to the content of the stories she also recorded the gestures used. The two groups did not differ in the overall likelihood of using gesture, but they showed a very large effect of perspective when gesturing about deer. Euro-American adults would “place” the deer in some location (using their hands) but a significant proportion of Menominee adults “became” the deer in gesture. They were reliably more likely to take the deer’s perspective in gesture than were Euro-American adults. More research is needed, but results so far indicate that this line of research will prove fruitful.

Direct learning is important in knowledge acquisition and several studies have been dedicated to this issue (see Ross 2002a,b, 2004; Shenton and Ross, undated; Stross 1973; Zarger 2002a,b; Zarger and Stepp 2004). Most of these studies have explored relations between activities and cultural change (see also Nabhan and St. Antoine 1993). We urge researchers to explore the effects that come with a decrease in expertise and the resulting limitations in the power of generating cultural knowledge (see Atran and Medin 2008; Atran et al. 2004; Shenton and Ross, undated). Knowing or not-knowing the name of a species should not be the endpoint of our inquiry but a starting point. (See Wolff et al. 1999 for an interesting study on changes in the specificity of plant knowledge in England based on a cross-time study using the online OED.) Research linking sophisticated consensus theory and social network analysis could explore *channels of information flow, content of information*, its impact on the individual mind, and *cognitive processing*.

WHAT IS CULTURE AND HOW DO WE STUDY IT?

We have talked much about culture and feel it is now time to say a little more about what we mean by it.

In our view, culture comprises both mental and public representations such as material productions, speech, and other aspects of behavior in particular ecological contexts (see Ross 2004; Sperber 1996). What we refer to as culture or cultural concepts are those representations that are relatively stable and systematically distributed in a population (Atran et al. 2005; Ross 2004; Ross and Medin, submitted). We see cultural processes as outcomes of the complex interaction of individual cognitive processes interacting with each other and with their social environment.

First, we avoid cross-cultural studies where “culture” is treated as an *independent variable*, which is inherently circular unless the notion is unpacked into a series of dimensions or values that could in principle be manipulated. In this case, however, the notion of culture

becomes empty and can be discarded. Calling differences “cultural” does not add to understanding.

Second, adopting this perspective forces us to perceive cognitive processes as *situated or embodied manifestations* (mental activities relevant to an individual’s life). They take place within a specific social and physical context. Consequently, it reinforces a research strategy of examining cognition in relevant contexts. It may be useful for some purposes to study cognition in highly artificial contexts, but only with an eye toward real-world relevance.

Third, this view of culture illuminates the interaction of cognitive and social processes. Cultural change involves conceptual change (within and across individuals) as well as changes in the distribution of specific concepts within populations. To the extent that the formation and transmission of concepts depends on the flux of information, it is important to widen our analysis of *information* to any kind of information input or cultural practice, and not focus solely on explicit propositional content. We focus on populations, and the distribution of representations among populations, with the goal of explaining patterns of agreement and disagreement. It is important to explain both *cultural stability/resiliency* and *cultural change* (Ross et al., submitted).

Fourth and finally, viewing culture as a distribution of ideas and practices avoids essentializing culture or defining it only in terms of consensus or agreement. Instead of treating disagreement as the failure to form or maintain a consensus, it becomes central to our distributional approach (it is signal, not noise). However, cultural differences with respect to categorization are in themselves a cause for further cultural differences.

CONCLUSION

This brings us back to the question: Is folkbiology a discrete domain? The correct answer should probably be “yes and no.” Cognitive scientists seem to come to terms with the idea that folkbiology is formed around some potentially innate skeletal principles. However, folkbiology also seems to be connected to folk-medicine, by virtue of concepts such as *alive*, *death*, and *sick*, and by the thousands of medicinal plants documented around the world. Exploring such common ground will likely produce increasingly complex accounts of how cultural beliefs and cognitive structure interact.

REFERENCES

- ATRAN S. The cognitive foundations of natural history: towards an anthropology of science. New York: Cambridge University Press; 1990.
- ATRAN S. Folk biology and the anthropology of science: cognitive universals and cultural particulars. *Behav Brain Sci* 1998;21:547–609
- ATRAN S, MEDIN DL. The native mind and the cultural construction of nature. Boston (MA): MIT Press; 2008.
- ATRAN S, MEDIN DL, ROSS N, LYNCH E, COLEY J, EK’ EU, VAPNARSKY V. Folkecology and commons management in the Maya Lowlands. *Proc Natl Acad Sci USA* 1999;96(13):7598–7603.
- ATRAN S, MEDIN DL, ROSS N, LYNCH E, VAPNARSKY V, EK’ EU, COLEY J, TIMURA C, BARAN M. Folkecology, cultural epidemiology, and the spirit of the commons. *Curr Anthropol* 2002;43(2):421–450.
- ATRAN S, MEDIN DL, ROSS N. Evolution and devolution of knowledge: a tale of two biologies. *J Roy Anthropol Inst* 2004;10(2):395–420.
- ATRAN S, MEDIN DL, ROSS N. The cultural mind: environmental decision making and cultural modeling within and across populations. *Psychol Rev* 2005;112(4): 744–776.
- BAILENSON JN, SHUM MS, ATRAN S, MEDIN DL, COLEY JD. A bird’s eye view: biological categorization and reasoning within and across cultures. *Cognition* 2002;84(1):1–53.
- BALÉE W. 1994. Footprints of the forest: Ka’apor ethnobotany: the historical ecology of plant utilization by an

- Amazonian people. New York: Columbia University Press; 2002.
- BANG M, MEDIN D, ATRAN S. Cultural mosaics and mental models of nature. *Proc Natl Acad Sci* 2007;104:13868–13874.
- BARSALOU LW. Deriving categories to achieve goals. In: BOWER GH, editor. *The psychology of learning and motivation*. New York: Academic Press; 1991. p 1–64.
- BERLIN B. *Ethnobiological classification*. Princeton (NJ): Princeton University Press; 1992.
- BERLIN B, BREEDLOVE DE, RAVEN PJ. General principles of classification and nomenclature in folk biology. *Amer Anthropol* 1973;75:214–242.
- BERLIN B, BREEDLOVE DE, RAVEN PJ. *Principles of Tzeltal plant classification*. New York: Academic Press; 1974.
- BOSTER JS. Agreement between biological classification systems is not dependent on cultural transmission. *Amer Anthropol* 1987;89:914–920.
- BOSTER J, BERLIN B, O'NEIL JP. The correspondence of Jivaroan to scientific ornithology. *American Anthropologist* 1986;88:569–583.
- BOSTER JS, D'ANDRADE R. Natural and human sources of cross-cultural agreement in ornithological classification. *Amer Anthropol* 1989;91:132–142.
- BOSTER JS, JOHNSON J. Form or function: a comparison of expert and novice judgments of similarities among fish. *Amer Anthropol* 1989;91:866–889.
- BURNETT R, MEDIN DL. Reasoning across cultures. In: RIPS L, ADLER J, editors. *Reasoning: studies of human inference and its foundations*. Cambridge (MA): Cambridge University Press; 2008.
- BURNETT R, MEDIN D, ROSS N, BLOK S. Ideal is typical. *Can J Exp Psychol* 2005;59(1):3–10.
- CAREY S. *Conceptual change in childhood*. Cambridge (MA): Bradford Books, MIT Press; 1985.
- CHRISOMALIS S. A cognitive typology for numerical notation. *Camb Archaeol J* 2004;14(1):37–52.
- COLEY JD, MEDIN DL, PROFFITT JB, LYNCH E, ATRAN S. Inductive reasoning in folkbiological thought. In: MEDIN DL, ATRAN S, editors. *Folkbiology*. Cambridge (MA): MIT Press; 1999.
- CONKLIN HC. *The relation of Hanunoo culture to the plant world [PhD dissertation]*. New Haven (CT): Yale University; 1954.
- CONKLIN HC. The lexicographic treatment of folk taxonomies. *Int J Am Ling* 1962;28:119–141.
- D'ANDRADE R. The cultural part of cognition. *Cog Sci* 1981;5:179–195.
- D'ANDRADE R. *The development of cognitive anthropology*. Cambridge: Cambridge University Press; 1995.
- DIAMOND J. *Avifauna in the Eastern New Guinea Highlands*. Cambridge: Cambridge University Press; 1972.
- ELLEN R. Ethnobiology, cognition, and the structure of prehension: some general theoretical notes. *J Ethnobiol* 1986;6:83–98.
- FRAKE CO. The diagnosis of disease among the Subanum. *Amer Anthropol* 1961;63:11–32.
- FRAKE CO. The ethnographic study of cognitive systems. In: GLADWIN T, STURTEVANT WG, editors. *Anthropology and human behavior*. Washington (DC): Anthropological Society of Washington; 1962. p 72–93.
- HUTCHINS E. Understanding Micronesian navigation. In: GENTNER D, STEVENS AL, editors. *Mental Models*. Hillsdale, NJ: Lawrence Erlbaum; 1983. p 191–225.
- HUTCHINS E. *Cognition in the Wild*. Boston (MA): MIT Press; 1995.
- INAGAKI K. The effects of raising animals on children's biological knowledge. *Brit J Dev Psychol* 1990;8:119–129.
- JOHNSON KE, MERVIS CB. Impact of intuitive theories on feature recruitment throughout the continuum of expertise. *Mem Cogn* 1998;26:382–401.
- La Torre Cuadros M, ROSS N. Secondary biodiversity: local perceptions of forest habitats among the Maya of Solferino, Quintana Roo, Mexico. *J Ethnobiol* 2003;23:287–308.
- LOPEZ A, ATRAN S, COLEY JD, MEDIN DL, SMITH EE. The tree of life: universal and cultural features of folk biological taxonomies and inductions. *Cogn Psychol* 1997;32:251–295.
- MEDIN DL, LYNCH EB, COLEY JD, ATRAN S. Categorization and reasoning among tree experts: do all roads lead to Rome? *Cogn Psychol* 1997;32:49–96.
- MEDIN DL, ROSS N, ATRAN S, BURNETT RC, BLOCK S. Categorization and reasoning in relation to culture and expertise. In: ROSS BH, editor. *The psychology of learning and motivation: advances in research and theory*. Volume 41. San Diego (CA): Academic Press; 2002.
- MEDIN D, ROSS N, COX D. *Culture and resource conflict: why meanings matter*. New York: Russell Sage Foundation Publications; 2006a.
- MEDIN D, ROSS N, ATRAN S, COX D, COLEY JD, PROFFITT JB, ET AL. Folkbiology of freshwater fish. *Cognition* 2006b;99:237–273.
- MEDIN DL, ROSS N, COX D, ATRAN S. Why folkbiology matters: resource conflict despite shared goals and knowledge. *Hum Ecol* 2007;35(3):315–329.
- MESSER E. Systematic and medicinal reasoning in Mitla folk botany. *J Ethnopharmacol* 1991;33:107–128.
- MILLER KF, SMITH CM, ZHU J, ZHANG H. Preschool origins of cross-national differences in mathematical competence: the role of number-naming systems. *Psychol Sci* 1995;6:56–60.
- NABHAN GP, ST. ANTOINE S. The loss of floral and faunal story: The Extinction of Experience. In: KELLERT SR, WILSON EO, editors. *The Biophilia Hypothesis*. Washington, DC: Island Press/Shearwater; 1993. p 232–256.
- NAKAO K, ROMNEY A. A method for testing alternative theories: an example from English kinship. *Amer Anthropol* 1984;86:668–73.
- NICKERSON DM. Dominance of the positive-part version of the James–Stein estimator. *Stat Prob Lett* 1988;7(2):97–103.

- NORMAN DA. Cognition in the head and in the world. *Cogn Sci* 1993;17:1–6.
- OSHERSON D, SMITH E, WILKIE O, LOPEZ A, SHAFIR E. Category-based induction. *Psychol Rev* 1990;97:85–200.
- PROFFITT JB, COLEY JD, MEDIN DL. Expertise and category-based induction. *J Exp Psychol Learn Mem Cogn* 2000;26(4):811–828.
- RANDALL R. How tall is a taxonomic tree? Some evidence for dwarfism. *Am Ethnol* 1976;3:543–553.
- RANDALL R. The nature of highly inclusive folkbotanical categories. *Amer Anthropol* 1987;89:143–146.
- ROMNEY A, WELLER S, BATCHELDER W. Culture as consensus: a theory of culture and informant accuracy. *Amer Anthropol* 1986;88:313–338.
- ROSCH E, MERVIS C, GRAY W, JOHNSON D, BOYES-BRAEM P. Basic objects in natural categories. *Cogn Psychol* 1975;8:133–156.
- ROSCH E, SIMPSON C, MILLER R. Structural basis of typicality effects. *J Exp Psychol* 1976;2:491–502.
- ROSS N. Bilder vom Regenwald: Mentale Modelle, Kulturwandel und Umweltverhalten bei den Lakandonen in Mexiko. Münster: LIT Verlag; 2001.
- ROSS N. Cognitive aspects of intergenerational change: mental models, cultural change, and environmental behavior among the Lacandon Maya of southern Mexico. *Hum Organ* 2002a;61(2):125–138.
- ROSS N. Lacandon Maya intergenerational change and the erosion of folkbiological knowledge. In: STEPP J, WYNNDHAM F, ZARGER R, editors. *Ethnobiology and biocultural diversity*. Athens: University of Georgia Press; 2002b. p 585–592.
- ROSS N. Culture and cognition: implications for theory and method. Thousand Oaks (CA): Sage Publications; 2004.
- ROSS N, MEDIN D. Culture and cognition: the role of cognitive anthropology in anthropology and the cognitive sciences. In: KRONENFELD ET AL., editors. *Handbook of cognitive anthropology*; submitted.
- ROSS N, TIDWELL M. Concepts and culture. In: MARESCAL D, QUINN P, LEA SEG, editors. *The making of human concepts*. Oxford: Oxford University Press; 2010. p 131–148.
- ROSS N, MEDIN D, COLEY JD, ATRAN S. Cultural and experimental differences in the development of folkbiological induction. *Cogn Devel* 2003;18(1):25–47.
- ROSS N, MEDIN DL, COX D. Epistemological models and culture conflict: menominee. *Ethos J Soc Psychol Anthropol* 2007;35(4):478–515.
- ROSS N, TIMURA CA, MAUPIN J. Stability in cultural emergent systems: globalization and cultural resiliency in folk medical beliefs. *Amer Anthropol*; submitted.
- SHAFTO P, COLEY JD, BALDWIN D. Availability in category-based reasoning. *Poster presented at the 46th Annual Meeting of the Psychonomic Society*. Toronto; 2005.
- SHENTON J, ROSS N. Maya folk botany and knowledge devolution: emerging intra community variability in plant knowledge among children and adults. Undated MS.
- SHEPARD GH, YU DW, NELSON BW. Ethnobotanical ground-truthing and forest diversity in the western Amazon. *Adv Econ Bot* 2004;15:133–171.
- SMITH E, MEDIN D. *Categories and concepts*. Cambridge (MA): Harvard University Press; 1981.
- SPERBER D. *Explaining culture: a naturalistic approach*. Oxford: Blackwell Publishing; 1996.
- STROSS B. Aspects of language acquisition by Tzeltal children [PhD dissertation]. Berkeley: University of California; 1970.
- STROSS B. Acquisition of botanical terminology by Tzeltal children. In: EDMONSON M, editor. *Meaning in Mayan languages*. The Hague: Mouton; 1973. p 107–141.
- TROPE Y, LIBERMAN N, WAKSLAK C. Construal levels and psychological distance: effects on representation, prediction, evaluation and behavior. *J Consum Psychol* 2007;17:83–95.
- UNSWORTH SJ. Storytelling and gesture practices support cultural variation in orientations toward nature. *Discourse, Culture, and Cognition* (Undated manuscript).
- WAXMAN S, MEDIN D, ROSS N. Folkbiological reasoning from a cross-cultural developmental perspective: early essentialist notions are shaped by cultural beliefs. *Dev Psychol* 2007;43(2):294–308.
- WOLFF P, MEDIN D, PANKRATZ C. Evolution and devolution of folkbiological knowledge. *Cognition* 1999;73:177–204.
- ZARGER R. Children's ethnoecological knowledge: situated learning and the cultural transmission of subsistence knowledge and skills among Q'eqchi' Maya. Athens: University of Georgia; 2002a.
- ZARGER R. Acquisition and transmission of subsistence knowledge by Q'eqchi' Maya in Belize. In: STEPP J, ET AL., editors. *Ethnobiology and biocultural diversity*. Athens: University of Georgia Press; 2002b. p 593–603b.
- ZARGER RB, STEPP JR. Persistence of botanical knowledge among Tzeltal Maya children. *Curr Anthropol* 2004;45(3):413–418.
- ZENT S. Acculturation and ethnobotanical knowledge loss among the Piaroa of Venezuela. In: MAFFI L, editor. *On biocultural diversity: linking language, knowledge, and the environment*. Washington (DC): Smithsonian Institution Press; 2001.
- ZENT EL, ZENT S. Los Jodí: sabios botánicos del Amazonas venezolano. *Antropologica* 2002;97–98:29–70.

Chapter 21

The Symbolic Uses of Plants

LUÍS MANUEL MENDONÇA DE CARVALHO

Botanical Museum-Instituto Politecnico de Beja, Portugal

INTRODUCTION	351
METHODS	352
SACRED TREES AND PLANTS	353
FLOWERS AS SYMBOLS	357
THE SYMBOLISM OF FRUITS AND SEEDS	358
THE SYMBOLISM OF PLANTS IN EUROPEAN PAINTINGS	361
NATIONAL AND POLITICAL SYMBOLS	362
PLANTS, PEOPLE, AND COLOR	365
THE SYMBOLISM OF PLANTS IN ARCHITECTURE, LITERATURE, AND MUSIC	366
REFERENCES	368

A sign is everything which can be taken as significantly substituting for something else. This something else does not necessarily have to exist or to actually be somewhere at the moment in which a sign stands in for it.

—Umberto Eco (1976)

Symbols can be as much involved with concealment as they can with revelation. That is the secret of symbols.

—Ilse Hayden (1987)

INTRODUCTION

Interest in signs existed throughout the history of philosophy from ancient Greece onwards, but the two primary contemporary theories come from the works of Ferdinand de Saussure

Ethnobiology. Edited by E. N. Anderson, D. Pearsall, E. Hunn, and N. Turner
© 2011 Wiley-Blackwell. Published 2011 by John Wiley & Sons, Inc.

(1857–1913), a Swiss linguist who coined the term semiology, a science that studies the role of signs as part of social life (Saussure 1983), and Charles Sanders Peirce (1839–1914), an American philosopher who devoted his studies to what he called semiotics, a formal doctrine of signs closely related with logic (Peirce 1931–1958). Subsequent semioticians have sought to identify and categorize the codes according to which signs are organized and also establish the theoretical foundations for a science which is still characterized by a host of competing theoretical assumptions (Chandler 2007).

Signs are commonly seen as meaningful units which are interpreted as standing for something else. They are found in the form of words, images, sounds, acts, body language, or objects, and have no intrinsic meaning, becoming signs only when users invest them with a meaning to a recognized code. This code is a system of related conventions for correlating the signifier (the form of the sign) and the signified (the mental concept) in specific domains, and provides the framework within which signs make sense to an interpretative community who share it. The symbol is a key concept in many fields, such as anthropology, theology, philosophy, and psychoanalysis, and in its narrowest sense, symbol is a class within signs (Nöth 1995).

An elementary symbol is an object or a living being who stands for a concept or an abstract quality often endowed with a larger dimension. Symbols may be spread far beyond their place of origin and were primarily used to unify or control societies.

Knowing the meaning of symbols allows us to interpret art, literature, or human achievements of the past with a deeper understanding and put us in touch with the mind-set of societies that developed codes of symbolism over thousands of years. For them, space and time were very different from the scientific concept of a universe governed by physical laws. The structures of mythology and symbolism grew out of societies that strongly believed life had a spiritual dimension and to whom symbols provided reassurance, group solidarity, or even ethical inspiration. Myths were themselves extended symbols systems, encapsulating religious, philosophical, or psychological truths based on written or oral memories handed down for centuries and dealing mainly with supernatural beings, remote events, religious and social customs. When compared with folk tales and sagas, myths had a more sacral symbolism; they explained mysteries, taught lessons about human life, and embodied social and private virtues that supported and strengthened the culture which created them (Tresidder 2004).

This chapter analyzes the symbolic uses of plants with only a few notes on animals; some classical references on this latter subject are Rowland (1978), Friedmann (1980), White (1991), Houlihan (1996).

Plant communities gave structure to the biological and cultural environments experienced by humans. They were the most reliable and available elements in the natural ecosystems, and soon began to play symbolic roles reflecting cultural needs. Their biological and physical properties, forms, and life cycles lend themselves as materials for earthly manifestations of primeval and divine forces, which used plants to interact and communicate with humans (Alcorn 1995). Although plants had a plethora of symbolic meanings, they frequently embodied positive achievements, virtues, and abstract concepts that revealed the best of nature, gods, and humans.

METHODS

In order to develop the correct methodology to study the symbolic role of plants in past and contemporary human societies, researchers need to have a research problem, select the

adequate conceptual model for the study, and identify and implement techniques suitable to the research question and field conditions. The decisions concerning these scientific options will determine how and what data will be collected, analyzed, and evaluated.

Classic manuals of ethnobotany (Alexiades 1996; Cotton 1996; Martin 2004; Schultes and Von Reis 1995), plant symbol compendia (Cleene and Lejeune 2002; Levi D'Ancona 1977), histories of art (Davies 2006) and others for specific research areas, provide the adequate basic knowledge, scientific concepts, and research tools needed for field and bibliographic research. This is an interdisciplinary area, which needs to be studied with a multidisciplinary approach from natural and social sciences, although the barriers traditionally created between different disciplines do not promote or facilitate it.

SACRED TREES AND PLANTS

In the past, people made sacrifices to trees in order to obtain favors from the spirits who inhabited them. Trees not only housed spirits and gods but were often symbols of eternal and continuous rebirth. The idea of a mighty and divine tree (“Tree of Life”) that formed a central axis for the flow of energy between the supernatural realms and the human world took many shapes. This tree, rooted in the Underworld and linking Earth to the Kingdom of Heaven, is an almost universal symbol, and sometimes becomes a metaphor for the whole creation. Even in our contemporary world, one of the main scientific goals of the twenty-first century is drawing a new Tree of Life, a genetic tree linking all living beings using phylogeny based on DNA analyzes—a new meaning for this ancient symbol.

In the Bible, the Tree of Life was located at the centre of the Garden of Eden, the birthplace of Man, where divine order ruled over all living beings. Contrasting with it was the “Tree of the Knowledge of Good and Evil,” with its forbidden fruits, which ultimately induced the fall of Man. Many traditions locate the Tree of Life in a sacred mountain or in paradisiacal realms where a fountain of spiritual nourishment would gush from its roots. Through this tree, humans could transcend their lower nature toward spiritual illumination, achieve salvation or release themselves from the cycle of eternal suffering. The images of Christ crucified on a tree rather than a cross refers to this ancient tree symbolism (Fig. 21.1).

The fruits of the Tree of Life can also grant immortality, like the peaches (*Prunus persica*) in Chinese Taoism. The legendary Heavenly Peach grows in the mythical gardens of the Queen Mother of the West, where the peach tree blooms and bears fruits once every 3000 years; humans who are invited to her table, and eat the peaches, can live forever (Birrell 1999).

In ancient Graeco–Roman mythology, gods ate or drank the fragrant ambrosia, thought to be a divine exhalation of Earth, and sweet nectar produced by flowers, in order to grant them eternal youth and perpetual wisdom. Other food-bearing trees have appeared as the Tree of Life: the sycamore fig (*Ficus sycomorus*) in Egypt; the olive (*Olea europaea*), the date palm (*Phoenix dactylifera*), and the pomegranate (*Punica granatum*) in the Middle East (Tresidder 2004). Their cosmic symbolism seems to have developed out of cults in which the trees were embodiments of the fecund Earth Mother. Fertility rites were usually centered upon trees, especially deciduous trees, whose bare winter branches and spring blossoms provided convincing symbols for the cycles of death and rebirth, a probable origin of the maypole, which is likely to be a tree-based fertility rite (Cleene and Lejeune 2002). Sometimes the cosmic tree can be reversed to show its roots drawing spiritual strength from Heaven, a favorite image in cabalism and other forms of mysticism. In India and

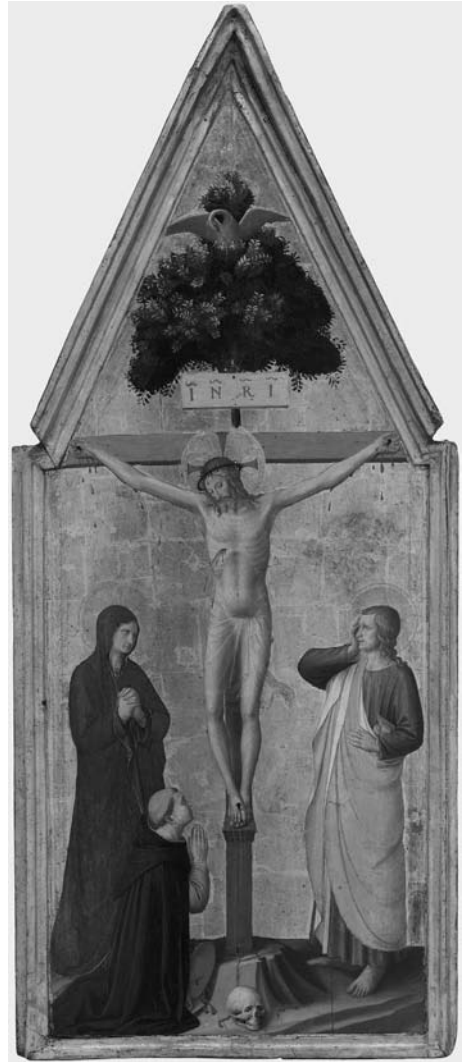


Figure 21.1 “Christ as the Tree of Life” (Fra Angelico, c. 1446; Christ on the Cross between the Virgin and Cardinal Torquemada and Saint John the Evangelist). © President and Fellows of Harvard College, Harvard Art Museums, Fogg Art Museum, Hervey E. Wetzel Bequest Fund, 1921.34 (Photo by Katya Kallsen).

southeast Asia, the sacred banyan tree (*Ficus benghalensis* and related species) is a model for the symbolism of an inverted cosmic tree, probably due to its extraordinary and powerful aerial roots and trunk, among which small shrines are sometimes built. The species *Ficus microphylla* is sacred in China because of its gnarled trunk, which seems shaped by flows of great power. Buddhists honor with special reverence the Bodhi tree (*Ficus religiosa*) planted near the Mahabodhi Temple (India), the earthly place where Buddha attained enlightenment.

The oak was one of the most widely venerated trees because in the mythological belief of many ancient European cultures it was a tree associated with the creation of humanity. To the Greeks, oaks were dedicated to Zeus; to the Romans it was Jupiter’s sacred tree, and to the Teutonic tribes the oak was Thor’s tree. It was the celestial tree of the Celtic Druids (“druid” comes from the Celtic word for oak) and all ceremonies and rites took place under it or in its vicinity. In Epirus (Greece), a region famous for its violent storms, dendromancy—the art of forecasting the future with the help of trees—was practiced at the Dodona Oracle.

The oak spoke through the voices of the priestesses who interpreted the rustling of the oak leaves (Herodotus 2008).

The olive tree was a blessed tree in the classical world, Hebrew, Christian, and Islamic religions, playing a central role in all civilizations that flourished around the Mediterranean Sea. The peace symbolism of the olive is very ancient. It was an olive branch that Noah's dove brought back from the Ararat Mountain as an advent of the new and peaceful era ready to begin. In Ancient Greece, the olive was the sacred tree of Athens, a gift from the goddess Athena who protected the city and its inhabitants, and wreaths of olive leaves crowned the winners at the Olympic Games, symbolizing everlasting glory and immortality (Baumann 1996). The Romans venerated the olive tree as a symbol of victory and crowned their squadrons of horseman with olive branches as a great mark of honor (Pliny 1991).

The olive is linked to the major Christian rituals; it is one of the plants of the Eucharist (with wheat and grapes) and is present at the four sacraments involving unction (anointing with olive oil): baptism, confirmation, ordination, and extreme unction at time of death. Later, in Islam, the olive tree was considered the axis of the world and the symbol of the Prophet Mohammed. During millennia, temples, churches, and mosques in the Mediterranean Basin and in its vicinity were illumined with olive oil, making it a perfect symbol of light.

In *Metamorphoses*, the Roman poet Ovid (1955) recounts how Daphne, a nymph pursued by Apollo, fled from his advances and was transformed into a laurel tree (*Laurus nobilis*). The laurel became sacred to Apollo, the god of music, poetry, and, above all, of prophecies and oracles. The holiest laurels were at Delphi. For the ancient Greeks, Delphi was literally the centre of the world: the meeting place of the two eagles released by Zeus from opposite ends of Earth. Impaling one another with their beaks, they fell to the ground and the site was marked by the sacred *omphalos*, or navel stone. Apollo established himself at Delphi after killing the serpent Python, guardian of the Castalia Spring, and provided counsels through the voice of his priestess, the pythia. The oracle issued prophecies, supported the democratic reforms in Athens and the Spartans' laws, and made pronouncements that led to the freeing of slaves and to the foundation of new city states. During her prophetic trance, the Delphic pythia always held firm a laurel branch in her consecrated hands (Plutarch 1936). At the Pythian Games, organized at Delphi every four years, winners were apportioned a laurel wreath (laureate), as were triumphant generals after their return. In this latter case, laurel was initially used as a symbolic purification after the bloodshed of the battlefield. Laurel wreaths were later adopted by Romans as a symbol of power, honor, and victory (Pliny 1991) and they have been in use for almost two millennia.

The linden or lime tree (*Tilia* sp.) played an important role in Germanic mythology, as in the legend of Siegfried (Sigurd) who killed a powerful dragon and became invulnerable after bathing in the dragon's blood. While doing this, a linden leaf landed on his back, between his shoulders blades, leaving this area vulnerable. Later he died from a wound received at that spot. This legend, like the analogous ones of the Greek Achilles and the Persian Esfandiyar, can be read as a symbolic metaphor to the illusions of human invulnerability. In some areas of Europe, the linden was the tree of justice, under which judges assembled, heard charges and defenses, and finally issued decisions. It was also the tree of friendship and community, a focal point for village life. In Eastern Europe, until recently, women poured out libations under linden trees, hoping to increase their fertility. This tradition goes back to primeval beliefs that linked women to linden trees and men to oak trees (Cleene and Lejeune 2002).

The date palm (*Phoenix dactylifera*) was one of the most ancient symbols of the Tree of Life and an emblem of triumph and victory. In North Africa, Arabia, and the Middle East, dates were a traditional food; an oasis full of date palms must have looked like a sight



Figure 21.2 Sunday Palm procession of penitential *nazarenos* wearing medieval robes and holding branches of olive and palm leaves (Zaragoza, Spain). © Tomás Vela Esperebé. (See color insert.)

of Heaven when caravans, after days or weeks in the desert, reached its vicinities. Palms were often offered to winners as an emblem of victory and triumph. Christians assimilated this ancient practice and received Christ in Jerusalem with palm leaves as He triumphantly entered into the city. This ritual is repeated every year prior to Easter, on Palm Sunday, as a remembrance symbol (Fig. 21.2). In religious paintings the palm leaf was adopted as a symbol of martyrdom, usually depicted with martyr saints who overcame death and are examples of triumph through self-sacrifice (Impelluso 2004).

The baobab (*Adansonia digitata*) has a special place in African religions and cosmogony. Throughout the continent there is a belief that ancestral spirits dwell in certain baobabs and traditional societies always paid reverence and deep respect for this sacred tree. It is symbolically connected with fertility, peace, and good omens, although the reverse can occur if the tree is disrespected (Wickens and Lowe 2008).

The sacred lotus (*Nelumbo nucifera*) is a plant deeply rooted in Asian cultures (Fig. 21.3). The lotus flower symbolizes rebirth, cosmic life, and ultimately creation itself. It was assimilated into various religions and beliefs from India to Japan. In Hinduism,



Figure 21.3 Buddhist monks in Doi Suthep Temple (Chiang Mai, Thailand) holding lotus flowers while praying. © Santino Livoti. (See color insert.)

a sacred lotus bloomed from the navel of Vishnu while He rested on the waters, and Brahma emerged from that divine flower. In the Buddhist iconography, Buddha is often depicted over an immaculate lotus and this plant represents bodily and mental purity floating above the muddy waters of attachment to earthly desires (Tresidder 2004). The “lotus” represented in Ancient Egyptian iconography was a different species, the fragrant blue water lily (*Nymphaea caerulea*), a symbol of rebirth that also had sexual connotations, hence the frequent depiction of people smelling and exchanging it (Hepper 2009). In Ancient Egypt erotic connotations were also attributed to the sweet-smelling ripe fruits of mandrake (*Mandragora officinarum*), a plant that has a negative connotation in European folklore, usually credited with magical powers and widely associated with sorcery and witchcraft (Manniche 2002).

Spices hold a unique place in the history of plant symbols. For almost two millennia they fueled the collective imagination of Europeans and Asians as no other group of plants ever did. They were symbols of the earthly paradise; their fragrance offered a glimpse of Heaven and was the perfume of sanctity. Ultimately, as a symbol of wealth, they were the driving force for the first global trading network, which shaped the contemporary world (Freedman 2008).

FLOWERS AS SYMBOLS

Since the dawns of civilizations, flowers have taken part in our daily life activities and celebrations. People chose flowers as presents for friends and relatives, for altars and shrines, or for wreaths placed over tombs. The allegorical symbology of flowers is extensive, as they can represent seasons (Fig. 21.4), virtues, the ages of man, or even political and geographic units. However, their use is commonly related to social interaction, and many rules govern the variety, color, and number of flowers that should be chosen for a particular occasion.



Figure 21.4 May *Maia*, a tradition linked with the rituals of spring (Beja, Portugal). (See color insert.)

Due to their radiate structure, flowers were often symbols of the sun, of the cosmic order, and the opening of flowers symbolized the manifestation of a primeval force. In the Japanese art of flower arrangement (classical Ikebana), the flower arrangement follows a strict scheme: the upper branch represents Heaven, the middle one humanity, and the lower, Earth. Humanity is the intermediary between Earth and Heaven. These three forces are to be brought together harmoniously in order to become one within the cosmos.

The double meaning of flowers is present in a variety of myths and legends, such as the genesis of anemone (*Anemone coronaria*), a flower that symbolizes the fragile transience of life. Anemones sometimes appear in depictions of the Crucifixion and are also identified with the flowers that sprang up from the place where the Adonis fell dead. The goddess Aphrodite knew that Adonis was destined to die while hunting and tried, in vain, to dissuade him from pursuing this activity. One day he was finally killed by a wild boar. When she found him dying, she turned his blood into anemones. Since then, they have been associated with premature death and grief. In Greek mythology, other flowers had similar genesis, such as hyacinths and narcissus (Baumann 1996; Ovid 1955).

In China some flowers have a highly symbolic meaning, especially those which flourish in winter, such as the flowering-apricot (*Prunus mume*) and the peach (*Prunus persica*). They bloom under harsh conditions and so are metaphors for human achievements against the hardships of life (Goody 1993). In other Asian countries, such as in India, the language of flowers can be seen in its overwhelming beauty at the traditional flower markets where passion for nature and symbolism blend with refined sensibilities.

In Europe most of the religious significance of medieval flowers was secularized in the Renaissance when flowers began to take on the symbolism that they had held during the Classical Period. Flowers became associated with humanity and with humanistic ideas. Discoveries of new plants by plant hunters and the organization of these discoveries within new scientific concepts contributed to the prominence of flowers in the eighteenth and nineteenth centuries. Flowers took on an expressive function in the romantic period, and the connotation of morality that they gained helped them to achieve the proper and necessary respectability. The Victorian world saw the dawn of a famous new language of flowers which was, essentially, a language of courtesy and love (Seaton 1995).

THE SYMBOLISM OF FRUITS AND SEEDS

The diversity of fruits is an expression of the ecological relations that plants establish with animals and the abiotic conditions of their ecosystems. In the Roman world, fruits were attributes of the nymph Pomona, and symbolized prosperity and earthly pleasures, but were also used to represent the abundance of Paradise (Grimal 1996). In European still-life paintings, fruits often illustrate the transience of life.

Seeds can assist people in their religious pursuits and rites, as the *rudraksha mala* rosaries, made with 108 rough seeds of *Elaeocarpus ganitrus*, have been doing for centuries (Fig. 21.5). These seeds, used by Hindus, Sikhs, and Buddhists for meditative prayers, have an unusual variation in the number of grooves that cover their surface. A common type has five divisions, and these are considered by Hindus to be the symbolic five faces of Shiva. The word *rudraksha* is probably derived from *Rudra* (Shiva) and *aksha* (eyes); one Hindu legend states that the *rudraksha* tree grew from a tear dropped by Lord Shiva after seeing human suffering (Chatterjee 2001).

The apple (*Malus pumila*) was widely regarded as a symbol for love and sexual desire, so it usually suggests temptation in Christian tradition, because of a totally incorrect equation



Figure 21.5 Pilgrim wearing a waist-coat and garlands made with rudraksha seeds (Palakhi procession, Alandi, Pune, India). © Milind Torney.

with the Tree of Knowledge of Good and Evil. Apples were present in several myths, as in the twelve works endured by the Greek hero Heracles who won the golden apple of immortality kept in the garden of the Hesperides. The golden apple of discord sent by the uninvited goddess Eris to the wedding of Thetis and Peleus was the primary cause of the Trojan War (Graves 1993). In our contemporary world, the unique anthropomorphic shape of the cocode-mer seed (*Lodoicea maldivica*), the largest seed in the plant kingdom, may be regarded as a quintessential symbol of eroticism, as some apples probably were in the Classical World (Lioonet 1986). The fruits of the vine are among the oldest symbols of fecundity and life. In Ancient Greece grapes were the emblem of Dionysus (Bacchus); the maenads (bacchantes), holding thyrses made of giant fennel (*Ferula communis*) and pine cones (*Pinus* spp.), were the famous women in his retinue. In the cult of Dionysus, wine was the potion that united humans and the god himself (Baumann 1996). In the West, wine has a very important religious role because Catholics believe that the ritual wine drunk during the Eucharist is Christ's redeeming blood and not a mere symbol. Wine is also ceremonially vital in Judaism, important in Zoroastrianism, and banned in Islam.

The unusual anatomy of the pomegranate, with its many red seeds enclosed within a leathery casing, led to many emblematic meanings, from cosmic diversity to loyalty towards the ruling monarch, or fertility in marriage. One of these meanings is singular because it is linked to the myth of eternal return. One day, when the Graeco–Roman goddess Persephone (Proserpine) was gathering flowers in a meadow, Earth opened and her uncle Hades (Pluto) appeared and carried her off to be his queen in the Underworld. Her sorrowing mother, Demeter (Ceres) sought her throughout the world, and as she did not find her, the fields did not generate any corn; man would have been doomed if Zeus (Jupiter) had not convinced Hades to let Persephone go. Before she left, Hades persuaded her to eat some seeds of a



Figure 21.6 Proserpine (Persephone) and the pomegranate—a symbol of eternal return. Dante Gabriel Rossetti, 1874. © Tate Gallery.

pomegranate, which she accepted, unaware of the consequences (Fig. 21.6). All those who ate something in the Underworld were not allowed a definitive departure, so she was forced to an eternal return. This Graeco–Roman myth explained the succession of seasons: the joy of reunited mother and daughter was spring and summer; the sadness of separation, autumn and winter (Baumann 1996; Graves 1993).

Every great civilization on Earth relied on the fruits (caryopses) of the grass family (Poaceae): wheat (*Triticum* spp.) and barley (*Hordeum vulgare*) in the Mediterranean World and Middle East; maize (*Zea mays*) in America; sorghum (*Sorghum bicolor*) in Africa; and rice (*Oryza sativa*) in Asia. In all these regions, grains were staple foods and symbolized the renovation of life. In iconography, ears of grains appeared as symbolic attributes of gods and goddesses. The Mesoamericans worshipped the maize god, while in the Inca Empire Zaramama was a fertility goddess represented as a woman made of maize stalks.

The plant lore resilience in some traditional societies can be a symbol of strength against forced assimilation. Such is the case of Brazilian *candomble* flora—a rich and complex lore of the African Diaspora (Voeks 1997)—and the ethnobotany of native communities in North America (Moerman 1998).

THE SYMBOLISM OF PLANTS IN EUROPEAN PAINTINGS

The Classical World associated plants with the pleasures of life and with the gods they worshiped; so did the early Christians, after they had emptied the flowers of their pagan meanings and began to relate them to the Virgin Mary and Christ. Medieval thought adapted the major symbolic codes of antiquity into a new theological conception of the cosmos, imposing a distinct dichotomy between good and evil. Romanesque art is very rich in symbols and the medieval illuminated manuscripts, especially the Books of Hours of kings and nobles, are sources of information about the symbolic use of plants.

A recurrent topic in medieval iconography was the *Hortus conclusus*, a small, enclosed garden with the Virgin Mary, the Christ child, and the plants and flowers of Heaven (Fig. 21.7), among them the Madonna lily (*Lilium candidum*) and violets (*Viola odorata*). This image was inspired by a passage from the biblical *Song of Songs* in which the garden was associated with purity. Sometimes the Tree of Knowledge and the Fountain of Life were also depicted. A unicorn depicted inside the garden represented the purity and self-sacrifice of Christ, a well established and understood association during the Middle Ages (Harvey 1981; Impelluso 2004).

The Renaissance movement brought a revival of the classical Greek and Roman cultures with the reading and translation of ancient manuscripts; some were brought back from the vanishing Byzantine Empire, others from the Muslim world of North Africa and Middle East. Humanists could also disseminate their thoughts via the newly invented printing press, and so the classical texts restored to the West some ancient symbolic plant codes and knowledge. The symbolic images of the Renaissance were profoundly influenced not only by antiquity but also by platonic philosophical thoughts and esoteric traditions from the Jewish Kabalah. During these centuries, plant allegories and metaphors were commonly used to represent intangible virtues and earthly desires. Among intellectuals, the work of art



Figure 21.7 The Medieval *Hortus Conclusus* (Upper Rhenisch Master, ca. 1415, Städel Museum, Frankfurt am Main). © Stadel Museum—ARTOTHEK. (See color insert.)

was seen as a second nature and an alchemical transmutation of matter. Artists used alchemical symbols to reformulate the fundamental stages of the world's creation, or to communicate, to a limited circle of initiates, a shared body of important moral and intellectual values. The world of art was enriched with dense symbolic meanings that are now difficult to perceive by the uninitiated contemporary observer. What looks like a simple group of plants or animals in a painting can hide a rich symbolic meaning, where every element is charged with a specific significance (see, e.g., Friedman 1980; Rowland 1978). During the late Renaissance, much of the iconographic repertory was published in a series of treatises, and artists used them to give an efficient expression to the most common symbols and their corresponding meanings. In the seventeenth and eighteenth centuries, the symbolic language that for so long was part of the humanistic culture was gradually emptied of its deeper meaning. The paintings of the nineteenth century romanticism and symbolism movements, as well as the surrealism of the twentieth century, reasserted an anti-naturalistic conception of art, which brought together new meanings for the plants, drawn from the imagination and the unconscious human mind. Contemporary observers must now reply to the challenge of reading hidden meanings of paintings, knowing that there is never a single, definitive interpretation to the complexity of references, subjects, and plant symbols treated in each individual masterpiece (Battistini 2005).

NATIONAL AND POLITICAL SYMBOLS

Throughout history, many plants became symbols of regions, countries, or political movements; such were the cases of the elusive *silphium* (*Ferula* sp.) from Cyrene; the swamp papyrus (*Cyperus papyrus*) from Egypt; the hybrid roses from England's Tudor War of the Roses; violets (*Viola odorata*) for Napoleon's restoration; the chrysanthemum (*Chrysanthemum* sp.) and the cherry tree (*Prunus x yedoensis*) blooms in Japan; or the carnation (*Dianthus caryophyllus*) revolution in Portugal.

The *silphium* was a North African plant discovered in the sixth century BC, in the mountains surrounding Cyrene, a Greek colony on the coast of present day Libya. It was traded for medical and culinary uses and over-exploited as a source of wealth, becoming extinct in the first century AD—the first recorded plant extinction. The naturalist Pliny the Elder wrote that the last plant was given to Emperor Nero, as a singular curiosity (Pliny 1991). Today, we can have a glimpse of *silphium* through iconographic analyses of coins from Cyrene (Fig. 21.8), which frequently depicted its unique plant (Koerper and Kolls 1999).

Over more than three millennia, the Nile Delta supported extensive papyrus swamps which supplied papyrus stems for the manufacture of the writing material of Antiquity; papyrus plants were ubiquitously depicted in wall paintings as well as a decorative motif in furniture, appearing even in the throne of Pharaoh Tutankhamun (Hepper 2009). Papyrus was Egypt's most valuable export and it revolutionized the way people kept records and exchanged information. No substitutes were as durable and lightweight until the development of pulped paper.

The War of the Roses was a series of bloody dynastic civil wars between supporters of the rival houses of Lancaster and York, each one represented by a different rose, for the throne of England (c. 1455–1487). The war ended with the victory of the Lancastrian Henry Tudor, who founded the House of Tudor. King Henry VII chose, at the end of the war, to symbolize peace through a new rose that combines the Lancaster red rose and York white rose into a single red and white Tudor rose.



Figure 21.8 *Silphium* coin from the Greek colony of Cyrene (c. 308–277 BC). Courtesy of CNG Auctions.

When Emperor Napoleon Bonaparte abdicated in 1814 he was immediately banished to the island of Elba; however, before leaving, he told to his followers that he would return when violets were again in season. As a result of this statement, violets became a symbol that his supporters recognized. When he finally escaped and reappeared in Paris, he was presented with a bouquet of violets and was called “Father of the Violets” (Cleene and Lejeune 2002; Coombs 2003). Later on, after his final defeat at Waterloo and the restoration of Louis XVIII to the French throne, violets became a symbol of sedition.

The chrysanthemum is the imperial flower of Japan, representing humility and the simple life. The Japanese Emperor seats on the Chrysanthemum Throne; the Imperial Seal of Japan also depicts a stylized form of this flower and the Supreme Order of the Chrysanthemum is the highest honorific order of the country. Also in Japan, the cherry blossom season is a highly popular social phenomenon of flower viewing, when people gather to celebrate under the trees. It reaches its zenith at the end of March or the beginning of April, proceeding from the south to higher altitudes and northward. Besides being a celebration festival, cherry blossoms are also an enduring symbolic metaphor to illustrate the transience of earthly existence.

The 1974 Carnation Revolution was a left-leaning military coup, which overthrew 48 years of dictatorship in Portugal, restoring civil rights and political liberties. During the event, people came into the streets to support the revolutionaries and stuck red carnations into the soldiers’ rifle barrels, thus exchanging bullets for flowers. Since then, in Portugal, carnations are symbols of liberty and political freedom, adding a new dimension to this flower meaning and an example of how flower symbolism can be constantly recreated.

Some plants achieved the informal status of national or regional symbol through their use in beverages; such are the cases of guarana (*Paullinia cupana*) in Brazil, mate (*Ilex paraguariensis*) in Argentina, kava kava (*Piper methysticum*) in Polynesia, whisky made with barley (*Hordeum vulgare*) in Scotland, sake made with rice (*Oryza sativa*) in Japan, tequila (*Agave tequilana*) in Mexico, port wine (*Vitis vinifera*) in Portugal, champagne (*Vitis vinifera*) in France and, recently, rooibos (*Aspalathus linearis*) in South Africa.

Many other plants are national symbols even though they are not native to the country which they now represent. Such is the case for pineapple (*Ananas sativus*) in the Philippines, where it is used for the national costume (piña barong) (Fig. 21.9), tea (*Camellia sinensis*) in Sri Lanka (former Ceylon), tulips (*Tulipa* sp.) in the Netherlands, coffee (*Coffea arabica*) in Colombia, and paprika/pimento peppers (*Capsicum* sp.) in Hungary.



Figure 21.9 The national costume of the Philippines—the *piña barong tagalog* made with pineapple fibers.

Although humans have probably used distinctive symbols to identify themselves and their groups since long ago, European heraldry established its earliest codes in the first half of the twelfth century. Knights and warriors found it necessary to identify themselves with a cloth bearing a coat-of-arms that depicted stylized elements such as flowers, leaves, fruits, and trees, or animal such as unicorns, horses, lions, or bears. The members of the same family or clan used the same basic pattern on their shields. The development of tournaments was contemporary with the beginning of heraldry, and these two arts evolved together. Trees were drawn with enlarged leaves and fruits for easy identification. If the tree was not specified, it was usually drawn as an oak tree shape, especially in areas where the oak was formerly worshiped, and flowers were often depicted in a generic form. Plants represented in the coat-of-arms were frequently chosen as an explicit reference to the family name or an allusion of its origin. Later on, coats-of-arms became more elaborate due to unions between the ruling classes and the subsequent combination of designs (Rosenberg 1939; Woodcock and Robinson 2001).

The most frequent symbolic trees used in the coat-of-arms were the oak (*Quercus*) and the pine (*Pinus*); the most common fruits were grapes (*Vitis*) and apples (*Malus*); among flowers, the most famous were the stylized *fleur-de-lis* (*Iris*) and the rose (*Rosa*). Abstract forms were also used, such as the trefoil (three petals), quatrefoil (four petals), and the cinquefoil (five petals). Nowadays, plants are still used in national emblems, which are contemporary versions of ancient coats-of-arms, such as olive leaves (*Olea europea*) in the USA, Portugal (Fig. 21.10), Italy, and Cyprus; oak leaves (*Quercus* sp.) in Latvia, Estonia, and Bulgaria; golden wattle blossoms (*Acacia pycnantha*) in Australia; the tulip flower (*Tulipa* sp.) in Iran; red maple leaves (*Acer saccharum*) in Canada; palm leaves (*Phoenix dactylifera*) in Malta; the pomegranate (*Punica granatum*) in Spain; laurel leaves (*Laurus nobilis*) in Greece; or wheat spikes (*Triticum* sp.) in China and New Zealand.



Figure 21.10 The Portuguese coat-of-arms with golden olive branches.

PLANTS, PEOPLE, AND COLOR

Color is a perception of the human mind responding to specific waves and particles that move through the universe. According to their energy and wavelength, humans will see and categorize them with different names: red, orange, yellow, green, blue, violet, among others. Frequently, the names of colors are associated with plants (rose, orange, lilac, olive, peach, cerise, lavender, indigo), animals (salmon, coral, peacock), or minerals (turquoise, aquamarine) (Berlin and Kay 1969; Saunders 2000).

Some colors from plant dyes are deeply linked with objects used by ethnic (indigo/Touareg) and religious groups (saffron/Buddhists), or with skilful artisans from located areas (red madder/Oriental rugs). In these cases, color has transcended its primary meaning as a result of coloring materials to become a symbol of specific human groups.

Blue is rare in plants and often results from the presence of natural pigments called anthocyanins, which have a physiological and an ecological role. The most famous blue in the dyer's palette, indigo (*Indigofera* spp.), is not a natural pigment that occurs freely in the plant cell but the result of an oxidation process induced by humans. Many contemporary cultures still dye their traditional costumes with indigo, from West Africa (Mali) and Arabia (Oman, Yemen) to Pakistan, India and China. Among them are the “Blue People of the Sahara” or the “People of the Veil”: the Touareg—a Berber nomadic group that lives and trades in the Sahara desert, from Mali and Niger to Algeria and Libya. Touareg adult males traditionally use the *tagelmust*, an indigo dyed garment, both a veil and a turban, which became a symbol of their ethnic group. The shining darkness of the *tagelmust* is also a symbol of status and wealth (Balfour-Paul 2000).

Saffron (*Crocus sativus*) is commonly known as the world's most expensive spice, due to its time-consuming harvesting and processing techniques. Its major growing areas are located in Spain, Iran, and Kashmir; saffron's main coloring agent is crocin, a carotenoid obtained from the flowers' styles and stigmas. Yellow saffron has a very high symbolism among Buddhists because it was the color chosen by Buddha to express His renunciation and humility. Traditionally, monks and nuns wear robes dyed with yellow saffron as a sign that they are following the path and the teachings of Buddha. Often, the less expensive yellow dyes present in turmeric (*Curcuma longa*) or jackfruit (*Artocarpus heterophyllus*) may also be used. In China, until the fall of the Qing Dynasty (1911), a bright yellow obtained from the fruits of gardenia (*Gardenia augusta*) was reserved for the emperors' ceremonial silk robes (Cardon 2003).

Handmade oriental rugs, from western and central Asia to India, owe their traditional red color to an organic compound (alizarin) extracted from the roots of the madder plant (*Rubia*

tinctorum). For centuries, this dye (Turkey red) was manufactured using a process which yielded a bright and lasting shade of red, difficult to replicate with any other plant dye. The floors of temples, mosques, tents, and private houses were traditionally covered with elaborate hand-knotted carpets depicting stylized plant motifs and geometric patterns over a matrix of red cotton, wool, or silk. These elaborate red carpets were epitomes of craftsmanship, wealth, and sometimes even characters in traditional folktales (flying or magic carpets), which themselves became symbols of Muslim and Eastern civilizations (Chenciner 2000).

Other plants play central roles in symbolic rites of passage; such is the case of henna (*Lawsonia inermis*) in Muslim, Jewish, Gypsy, Zoroastrian, Sikh, and Hindu marriages. The symbolic use of henna is linked with fertility, but it is also considered sensual and used as a beautifying agent to decorate, with intricate motifs, the hands and feet of the brides.

The color obtained from plants can also give rise to the names to countries, as in Brazil, named after *pau-brasil* (*Caesalpinia echinata*), because the wood of this tree resembled red-hot embers (*brasa*, in Portuguese). The name *pau-brasil* had been used earlier to describe another Asian species (*Caesalpinia sappan*), which also produced a red dye, but the South American trees soon became the main source of the red coloring agent (Cardon 2003). Nowadays, the species *Caesalpinia echinata* is a symbol of nature conservation (it has endangered species status), of Brazil (it has been the national tree since 1978), and also of excellence (it is the best wood for the bows used in stringed instruments).

Although some colors from plant dyes have highly symbolic connotations, no color was more celebrated, and simultaneously less known, than purple, especially Tyrian purple obtained, after a long and costly process, from the sea mollusk *Bolinus brandaris* (*Murex brandaris*), which lives on the shores of present-day Lebanon (former Phoenicia). In the classical Roman and Byzantine Empires this was the color of power; the emperor of Byzantium held the title of *porphyrogenitus* (literally, *born in the purple*) as the highest symbol of secular power (Cardon 2003).

THE SYMBOLISM OF PLANTS IN ARCHITECTURE, LITERATURE, AND MUSIC

When tree worship was common in pagan religions, forest groves were sanctuaries where gods revealed their presence. Correspondence between columns and trees sustains the hypothesis that the archaic temples, Romanesque churches, and Gothic Cathedrals were symbolic adaptations of sacred groves. The Gothic cathedral resembles an ancient grove, with its columns rising toward the sky and curving like trees converging into a canopy, while stained glass windows let in the light as breaks in the tree foliage (Harrison 1993).

We can find examples of plant motifs in architecture back to Ancient Egypt, when architects adopted papyrus inflorescences as models for the capitals of columns. In Graeco-Roman architecture, the ornate Corinthian capital was decorated with another plant motif: stylized acanthus leaves (*Acanthus mollis*) (Baumann 1996). Although of Greek origin, the Corinthian order was more common in Roman architecture. In western Europe and America, the Corinthian capital was used extensively during the classical revivalism movement of architecture, until the early years of the twentieth century.

A classic element in architecture was the rosette, a carved or sculptured ornament with a circular arrangement of all parts radiating out from the centre, suggesting the petals of a rose (*Rosa* sp.). Another element suggesting the pattern of rose petals is the rose window. The origin of the rose window has many roots, but it is strongly connected with the Gothic period when, due to advancements in construction, large windows took the place of walls

and paintings were replaced with stained glass. As they did not have the technology to make large panes, they made small, colored panes, arranged in patterns. The combination of stained glass with ribbed vaulting allowed greater space, while flying buttresses allowed higher walls that opened the building. The religious instructional aspect of rose windows is visible when we analyze the subjects chosen for display in each petal. Typically, Christ or the Virgin Mary is found in the centre, with the saints, virtues, or events of the calendar year depicted in each petal (Cowen 2005; Williams 1999).

Literature is a powerful source of information about past and contemporary cultural uses of plants. Through folk tales, sagas, myths, or literary masterpieces we can glimpse vanished civilizations and gain a better understanding of the cultural context in which specific plants were used for symbolic meaning. The Homeric Iliad and Odyssey, the tragedies of Aeschylus, Euripides, and Sophocles, are not only literary masterpieces but priceless sources of information about plant symbology since the Greek Mycenaean Period down to the Hellenistic. In other masterpieces of literature, such as the great Sanskrit epic poems, Mahabharata and Ramayana, central to the whole of Indian culture, plants are continuously used for symbolic meaning (Brockington 1998).

In Shakespeare's plays, characters frequently turn to plants and flowers to express their deepest feelings, such as Ophelia in Hamlet. An example is her dialogue with Laertes:

OPHELIA: *There's rosemary, that's for remembrance. Pray you, love, remember. And there is pansies, that's for thoughts.*

LAERTES: *A document in madness, thoughts and remembrance fitted.*

OPHELIA: *There's fennel for you, and columbines. There's rue for you, and here's some for me. We may call it herb of grace o' Sundays. O, you must wear your rue with a difference. There's a daisy. I would give you some violets, but they withered all when my father died. They say he made a good end.* (Shakespeare 1998)

In music, the most obvious presence of plants is through the raw materials used in instruments, but these can transcend their primary use and become cultural symbols, such as the



Figure 21.11 Bernie Boston's iconic photo of anti-war demonstrators (1967). © Getty Images—The Washington Evening Star Collection.

case of castanets in Spain, which are a national symbol often played by traditional singers or dancers. The Spanish name (*castañuelas*) is a diminutive form of the word used for chestnut fruits (*Castanea sativa*), which they resemble.

In the Andes region, *sikuri* music based on panpipes made with reeds or bamboo became a symbol of the Andean culture, just as maracas, idiophone instruments made of coconut shells (*Cocos nucifera*) or gourds (*Crescentia cujete*) epitomize Caribbean music.

In the early eighteenth century, in Cremona (Italy), the luthier Stradivarius created his now-famous violins using slow growth wood and plant resins as varnishes. Nowadays, these violins are symbols of wealth and career achievement for those who have the rare opportunity to own or play them. Its reputation is so high that Stradivarius name is commonly invoked as a symbol of excellence in other unrelated areas.

Songs like *San Francisco (Be Sure to Wear Flowers in Your Hair)* by Scott McKenzie or the earlier *Where Have All the Flowers Gone?* written by Peter Seeger, are two examples of how flowers' classic association with peace and anti-war militancy was used in iconic hymns of the 1960s (Fig. 21.11). The former was the song of the 1967 "Summer of Love", a mythic gathering of hippies and young people collectively known as the "Flower Power Generation".

The cultural needs of humanity have embodied plants with anthropogenic concepts that expose clues to the evolution of the human mind and continuously add new dimensions to the history of man and plants. The study of past and contemporary symbolic uses of plants reveals elaborate forms of representation and communication as well as refined conceptions of comic order, religious beliefs, and artistic codes. Its study also reverses the unnatural division of human knowledge into discrete disciplines, a trend that future researches will certainly deepen, strengthen, and expand.

REFERENCES

- ALCORN J. The scope and aims of ethnobotany in a developing world. In: SCHULTES RE, VON REIS S, editors. *Ethnobotany: evolution of a discipline*. Portland (OR): Dioscorides Press; 1995. p 23–39.
- ALEXIADES M, SHELDON J, editors. *Selected guidelines for ethnobotanical research: a field manual*. New York: New York Botanical Gardens Press; 1996.
- BALFOUR-PAUL J. *Indigo*. London: British Museum Press; 2000.
- BATTISTINI M. *Symbols and allegories in art*. Los Angeles (CA): J. Paul Getty Museum Publications; 2005.
- BAUMANN H. *The Greek plant world in myth, art and literature*. Portland (OR): Timber Press; 1996.
- BERLIN B, KAY P. *Basic color terms—their universality and evolution*. Berkeley: University of California Press; 1969.
- BIRRELL A. *Chinese mythology: an introduction*. Baltimore (MD): Johns Hopkins University Press; 1999.
- BROCKINGTON J. *The Sanskrit epics*. Leiden: Brill Academic Publishers; 1998.
- CARDON D. *Le monde des teintures naturelles*. Paris: Belin; 2003.
- CHANDLER D. *Semiotics: the basics*. New York: Routledge; 2007.
- CHATTERJEE G. *Sacred Hindu symbols*. New Delhi: Abhinav Publications; 2001.
- CHENCINER R. *Madder red—a history of luxury and trade*. Richmond (UK): Curzon Press; 2000.
- CLEENE M, LEJEUNE MC. *Compendium of symbolic and ritual plants in Europe*. Volumes 1 and 2. Ghent: Man and Culture Publishers; 2002.
- COOMBS R. *Violets: the history and cultivation of scented violets*. London: Batsford; 2003.
- COTTON C. *Ethnobotany: principles and applications*. Chichester: John Wiley & Sons; 1996.
- COWEN P. *The rose window: splendor and symbol*. New York: Thames & Hudson; 2005.
- D'ANCONA ML. *The garden of the Renaissance: botanical symbolism in Italian painting*. Firenze: L.S. Olschki; 1977.
- DAVIES P, DENNY W, HOFRICHTER F, JACOBS J, ROBERTS A, SIMON D. *Janson's history of art: the Western tradition*. 7th ed. Upper Saddle River (NJ): Prentice Hall; 2006.
- ECO U. *A theory of semiotics*. Bloomington: Indiana University Press; 1976.
- FREEDMAN P. *Out of the East: spices and the medieval imagination*. New Haven (CT): Yale University Press; 2008.
- FRIEDMANN H. *A bestiary for Saint Jerome—animal symbolism in European religious art*. Washington (DC): Smithsonian Institution Press; 1980.
- GOODY J. *The culture of flowers*. Cambridge: Cambridge University Press; 1993.

- GRAVES R. *The Greek myths: complete edition*. New York: Penguin; 1993.
- GRIMAL P. *The dictionary of classical mythology*. Malden: Blackwell Publishers; 1996.
- HARRISON R. *Forests: the shadow of civilization*. Chicago (IL): University of Chicago Press; 1993.
- HARVEY J. *Medieval gardens*. Beaverton (OR): Timber Press; 1981.
- HAYDEN I. *Symbol and privilege—the ritual context of British royalty*. Tucson: Arizona University Press; 1987.
- HEPPER N. *Pharaoh's flowers—the botanical treasures of Tutankhamun*. 2nd ed. Chicago (IL): KWS Publishers; 2009.
- HERODOTUS. *The histories* (trans. WATERFIELD R). New York: Oxford University Press; 2008.
- HOULIHAN P. *The animal world of the Pharaohs*. New York: Thames and Hudson; 1996.
- IMPELLUSO L. *Nature and its symbols*. Los Angeles (CA): J. Paul Getty Museum Publications; 2004.
- KOERPER H, KOLLS WL. The Silphium motif adorning ancient Libyan coinage: marketing a medicinal plant. *Econ Bot* 1999; 53(2):133–143.
- LIOONET G. *The romance of a palm—Coco-de-Mer. Mauritius: L'Ile aux Images*; 1986.
- MANNICHE L. *Sexual life in ancient Egypt*. London: Kegan Paul International; 2002.
- MARTIN G. *Ethnobotany—a methods manual*. London: Earthscan; 2004.
- MOERMAN D. *Native American ethnobotany*. Portland (OR): Timber Press; 1998.
- NÖTH W. *Handbooks of semiotics*. Bloomington: Indiana University Press; 1995.
- OVID. *Metamorphoses* (trans. HUMPHRIES R). Bloomington: Indiana University Press; 1955.
- PEIRCE C. *Collected papers. Volumes 1–8*. Cambridge (MA): Harvard University Press; 1931–1958.
- PLINY. *Natural history: a selection* (trans. HEALY J). London: Penguin Classics; 1991.
- PLUTARCH. *Moralia. Volume 5* (trans. BABBITT F). Cambridge (MA): Harvard University Press; 1936.
- ROSENBERG M. *The art of heraldry*. New York: Henry Holt and Company; 1939.
- ROWLAND B. *Birds with human souls: a guide to bird symbolism*. Knoxville: University of Tennessee Press; 1978.
- SAUNDERS B. Revisiting basic color terms. *J Roy Anthropol Inst* 2000; 6:81–99.
- SAUSSURE F. *Course in general linguistics*. London: Duckworth; 1983.
- SCHULTES R, VON REIS S, editors. *Ethnobotany: evolution of a discipline*. Portland (OR): Dioscorides Press; 1995.
- SEATON B. *The language of flowers: a history*. Charlottesville: University of Virginia Press; 1995.
- SHAKESPEARE W. *Hamlet*. New York: Penguin; 1998.
- TRESIDDER J. *The complete dictionary of symbols in myth, art and literature*. London: Duncan Baird Publishers; 2004.
- VOEKS R. *Sacred leaves of Candomblé: African magic, medicine, and religion in Brazil*. Austin: University of Texas Press; 1997.
- WHITE D. *Myths of the Dog-Man*. Chicago (IL): University of Chicago Press; 1991.
- WICKENS G, LOWE P. *The Baobabs: Pachycauls of Africa, Madagascar and Australia*. Berlin: Springer-Verlag; 2008.
- WILLIAMS K. Spirals and rosettes in architectural ornament. *Nexus Netw J* 1999; 1(1–2):129–138.
- WOODCOCK T, ROBINSON J. *The Oxford guide to heraldry*. New York: Oxford University Press; 2001.

Chapter 22

Learning Ethnobiology: Creating Knowledge and Skills about the Living World

REBECCA K. ZARGER

Department of Anthropology, University of South Florida, FL

INTRODUCTION	371
A SHORT HISTORY LESSON: LEARNING ETHNOBIOLOGY	374
WORK, PLAY, LEARN: GAINING EXPERTISE WITH THE NONHUMAN WORLD	377
KEY INSIGHTS ON LEARNING ETHNOBIOLOGY	378
AGE AND DEVELOPMENT OF EXPERTISE	378
METHODS FOR DOCUMENTING THE PROCESS OF LEARNING ETHNOBIOLOGICAL KNOWLEDGE AND SKILLS	381
ETHNOBIOLOGY INSIDE AND OUT: APPLYING WHAT WE KNOW	383
REFERENCES	384

INTRODUCTION

For many decades, ethnobiologists have documented the systematic and complex ways humans perceive, categorize, and use the natural environment. Building on early work in ethnoscience (Conklin 1969; Sturtevant 1964), we now have a significant set of rich, cross-cultural appraisals of how humans tend to break up the natural world into meaningful categories, as well as connections and disjunctures between Western scientific systems of classification and “folk” classification systems from around the world (for important examples see Berlin 1992, Berlin et al. 1974, Hunn 1977, Medin and Atran 1999). Despite the generalizations that can now be made about how people relate to the nonhuman world, very little attention within the field has been focused on the question of *how* humans go about learning the intricacies of the landscapes they inhabit. This chapter addresses this

very question: “How do we learn the environmental knowledge¹ and skills that allow us to make a living, attach meanings, and pass on shared expertise to subsequent generations in particular landscapes?”

When I was a student in search of a research topic that would grab my attention for the next several years of my life (or longer as it turns out) as I pursued my doctorate in anthropology, I remember very clearly when I realized my interest in the “how” question with regards to learning environmental knowledge. In 1997 I was riding with a friend on the winding mountainous road between Tenejapa center and San Cristobal in Chiapas, Mexico. As we rounded a corner, I saw off in the distance a group of Maya children, dressed in dark wool tunics, leading a small herd of sheep in a line along the ridge. There were no adults, but the kids clearly knew what they were doing and where they were going.

I wondered how they could be so competent at such a young age, and reflected on how different their skills were from children I knew at home in the United States. I wanted to know more, and thought with a jolt that much attention had been paid by ethnobiologists and other researchers to the issue of “what” people know about the environment, but we needed to understand more fully the “how” part of the equation, since it is so fundamental to the persistence and resilience of knowledge of particular landscapes. Since that time, researchers have discovered some interesting patterns about the “out-of-school” or “informal” education that children participate in around the globe as they develop expertise, skills, and in-depth understandings of the places they call home. Paramount in this new area of research is a conceptualization of ethnobiological knowledge as much more than the ability to identify plants, birds, and other animals and knowing how they are used. This is something that ethnobiologists know from years of collecting data in the field as they combine skills in linguistics, biology, and ethnography among others (for a personal reflection on this process, see Hunn 2008: 13). Environmental knowledge is embodied knowledge, skills gained through years of first-hand experience immersed in a particular landscape, and practical know-how shaped by culturally situated practice (Anderson 2011; Ingold 2000, 2003; Lave and Wenger 1991; Rogoff 1990; Vermonden 2009; Wyndham 2010; Zarger 2002a, 2010). Focusing research directly on the experience of knowledge-as-action, learning-through-doing, or what Ingold calls the process of “enskilment” gained through “engagement” (Ingold 2000: 416) in the “dwelt-in world” (Ingold 2003: 310) has been a relatively new endeavor for ethnobiology over the last decade or so.

In this discussion, I trace the development of a focus on the process of learning ethnobiology, consider some pressing questions that researchers are beginning to find some answers to, evaluate the methods often used in studies of acquisition and knowledge variation, and briefly explore case studies that illustrate the ways ethnobiologists currently go about understanding learning during childhood and adulthood. This is not a broad

¹In this chapter I have chosen to use the inclusive term “environmental knowledge” because it is in my view preferable to “traditional ecological knowledge”/“TEK” or “indigenous knowledge,” which are often applied to the same phenomena but presuppose indigeneity, when people who share environmental knowledge may or may not be considered “indigenous”; determining what is “traditional” is equally problematic (for an extensive review of the history of indigenous knowledge see Zent 2009). A classic, workable definition of environmental knowledge is that by Berkes (1993: 3), “a cumulative body of knowledge and beliefs, transmitted from one generation to the next, about the relationship of living beings with one another and with their environment.” However, as we will see in this chapter, there are also problems with thinking of learning such relationships as “transmission”—which implies a one-way process of transfer of information, as if individuals were walkie-talkies instead of people. Also, information is not just shared between generations, from elders to young people, but is often learned from peers or older siblings. Finally, I include “skills” as well as knowledge in my treatment here because of the documented inseparability of knowledge and skills through practical experience and expertise in a particular landscape (based on my own research and others, see for example Ingold 2000: 162; 2003).

interdisciplinary review of the topic, which would include works from psychology, linguistics, environmental education, and four-field anthropology as well as ethnobiology (for a brief account of this type, see Zarger 2010). The emphasis here is to synthesize research on learning, particularly during childhood, carried out by ethnobiologists. Finally, the chapter concludes with a consideration of the application of what we know about learning ethnobiology.

Without early foundational research on *what* people know about the living world, particularly the development of widely agreed upon methods for describing ethnobiological classificatory systems, it would be impossible for researchers to consider how they come to be *shared* knowledge and skills. For much of the history of the field, ethnobiologists have tended to focus on “culturally competent adults rather than children” (Medin and Atran 1999: 5). Focusing on the most knowledgeable people in traditional societies, particularly elders or specialists, is sensible given a goal of documenting human universals in classification as well as the encyclopedic knowledge that humans have amassed about the

Table 22.1 Key Questions for Studies About Learning Ethnobiology

Key questions: learning ethnobiology	Relevant studies
How do children experience the process of learning the names, uses, and cultural significance of the living world?	Cruz Garcia 2006; Hunn 2008; Kahn 1996; Katz 1989, 2004; Ruddle 1993; Ruddle and Chesterfield 1977; Setalaphruk and Price 2007; Stross 1969; Wyndham 2010; Zarger and Stepp 2004
How do novices become experts in ethnobiological knowledge?	Atran and Medin 2008; Coley et al. 1999; Johnson and Mervis 1997; Medin and Atran 2004; Nolan 2002; Waxman 1999; Ross et al. 2003
What types of environmental knowledge do children learn first, and why might this be the case?	Waxman 1999; Waxman et al. 2007; Wyndham 2010; Zarger 2002a
How do experiences during childhood relate to adult expertise?	Chipeniuk 1995; Cruz Garcia 2006; Vermonden 2009
What variation exists in how we learn about the living world and how might this process be changing?	Alexiades 2009; Ellen and Harris 2000; Heckler 2009; Vermonden 2009; Wyndham 2010
Is ethnobiological knowledge being “lost” or “eroded,” or is it resilient in the face of change?	Atran et al. 2004; Bates et al. 2009; Godoy et al. 2009; Nabhan and St. Antoine 1993; Quinlan and Quinlan 2007; Reyes Garcia et al. 2005; Ross 2002; Zarger and Stepp 2004; Zent 2001; Zent and Zent 2004
Are particular types of knowledge and skills learned in a certain way, at certain times during childhood and beyond?	Hewlett and Cavalli-Sforza 1988; Lancy 2008; Zarger 2002a,b, 2010
How do social categories of difference, such as age, formal education, gender, occupation, and religious affiliation relate to the distribution and/or acquisition of environmental knowledge?	Quinlan and Quinlan 2007; Reyes-Garcia et al. 2010; Ross 2002; Ruiz-Mallen et al. 2009; Wyndham 2010; Zent 2009
How do social networks affect the distribution of environmental knowledge?	Ohmagari and Berkes 1997; Vermonden 2009; Wyndham 2010; Zarger 2002a

nonhuman world. And yet, a better understanding of the acquisition and development of knowledge and expertise—especially during childhood—provides a more nuanced understanding of how humans conceptualize, shape, and interact with their living worlds.

Researchers have begun to seriously examine the ways we learn about the environment around us, what shapes the distribution of environmental knowledge, and how it changes over time. This knowledge has often been treated as a static entity, but is in fact a dynamic body of information that has changed over time and is being transformed by processes of “globalization,” new resource strategies, and widening inequalities (Alexiades 2009; Ellen and Harris 2000; Heckler 2009). We are just beginning to understand the long-term, lifelong process of learning about the living world around us—how we come to know, use, and assign meaning to plants, animals, and other aspects of local ecologies. Ethnographically grounded research suggests that cross-culturally, humans acquire extensive environmental knowledge and skills during childhood, and may continue to refine and add to that knowledge throughout their lives (Cruz Garcia 2006; Dougherty 1979; Hunn 2002, 2008; Katz 1989, 2004; Ohmagari and Berkes 1997; Ross 2002; Ruddle and Chesterfield 1977; Setalaphruk and Price 2007; Stross 1969, 1973; Wyndham 2002, 2010; Zarger 2002a,b, 2010; Zarger and Stepp 2004; Zent and Zent 2004). There are a variety of key questions in this growing body of research, summarized in Table 22.1, which focuses primarily on ethnobiological studies. There are some compelling answers to the questions emerging from the research cited in Table 22.1. As we will see in the discussion that follows, the questions are part of a trend in ethnobiology to view environmental knowledge as dynamic and changing and to design studies in order to better understand how and why this is the case in different cultural contexts. Tracing the connections of these studies to previous work in the discipline is important to historicize and contextualize the discussion.

A SHORT HISTORY LESSON: LEARNING ETHNOBIOLOGY

Although a relatively recent concern for the field of ethnobiology, many anthropologists paid close attention to the process of learning the environment during childhood early on in the development of the discipline. Seminal works by Margaret Mead (1928), Gregory Bateson (1936), and Meyer Fortes (1938) each contributed important insights into what we know about the roles environment and subsistence played in children’s activities, socialization, and child-rearing practices from a cross-cultural perspective. Many other monographs in the first half of the twentieth century incorporated in-depth descriptions of how children contribute to their households and communities by hunting, foraging, farming, preparing food, and animal husbandry, as a part of a larger study documenting the lifeways of a particular “culture.” The extensive systematic cross-cultural studies in the 1950s and 1960s (epitomized by the “Six Cultures Studies” guided by the Whittings and carried out by their students) also documented how childrearing varies with subsistence strategies and local ecologies (Barry et al. 1959; Welch 1980; Whiting and Whiting 1975). Meanwhile, in the developing field of ethnobiology, researchers were developing methods to elicit knowledge, considering the relationships between “folk” classification systems and Western scientific nomenclature, and theorizing about what this information suggests about the universals and particulars of human cognition (Atran 1990; Berlin 1992; Hunn 2007)

An important step linking earlier studies in ethnobiology to investigations of learning processes were researchers who began to consider patterns of variation in ethnobiological knowledge. Boster’s study of variability in the knowledge of manioc varieties among the Aguaruna (Boster 1986), and later discussions as to whether the recognition of biological

species was dependent on cultural transmission are good examples of this trend (Boster 1987, 1996). Acknowledging that individuals might differentially share knowledge and that it varied within and between social groups was somewhat controversial at first (cf. Boster 1987), but eventually gained wider acceptance during the 1990s as researchers encountered economies in increasingly intensive interaction with global economies and exchanges of information (Ellen and Harris 2000; Reyes-Garcia et al. 2007a). For example, studies of knowledge variation describe: how gender relates to knowledge variation (Howard 2003; Keith 2005); how novices and experts differ in their categorization of wild plants (Nolan 2002); the impact of globalization, consumerism, and commercial occupation on medicinal plant knowledge (Quinlan and Quinlan 2007); and the consequences of environmental change, economic “development,” and migration into new environments on environmental knowledge (Bicker et al. 2004; Pieroni and Vandebroek 2007; Reyes-Garcia et al. 2005).

In a survey of studies of individual knowledge variation, Reyes-Garcia and collaborators assessed the types of methods used in a selection of 34 studies of ethnobotanical knowledge. They found that what “counts” as ethnobotanical knowledge varied from one study to the next, but that research on variation had increased dramatically from 1986 to 2005 (starting with Boster’s manioc study cited above). These authors argue that future research should increase systematicity and replicability in order to provide better comparability across studies and drive the field’s theoretical and methodological assumptions forward (Reyes-Garcia et al. 2007b). Zent (2009) echoes this call, suggesting that a shift towards studying knowledge change, variability, and transmission represents a “processual” trend in the field of ethnobiology and studies of Indigenous knowledge. This is not too dissimilar in many ways from Orlove’s (1980) account of the development of ecological anthropology. Many of the methods developed to document knowledge variation have been adapted to describe differences in ethnobotanical knowledge between individuals of different ages or as a proxy for change in environmental knowledge or skills over time, in lieu of long-term panel studies (Quinlan and Quinlan 2007; Reyes-Garcia et al. 2005; Ross 2002; Wyndham 2010; Zarger 2002a,b; Zarger and Stepp 2004; Zent and Zent 2004). An exception is the long-term Tsimane Amazonian Panel Study by Ricardo Godoy, Victoria Reyes-Garcia and colleagues who are studying how botanical knowledge, nutrition, health, and other aspects of daily life are changing as a result of “modernization” in Tsimane communities in the Bolivian Amazon. (See their project website <http://www.tsimane.org/> for an extensive list of publications). A more detailed discussion of the methods used to document environmental knowledge and skills follows below.

Another area of research, driven primarily by psychological, experimental research designs, but also the result of collaboration between cross-cultural psychologists, cognitive scientists, and ethnobiologists, is interest in the development of expertise and the so-called “transition from novice to expert.” How do those who know (experts) differ from those who don’t know (novices, or often children) in how they categorize and make sense of the natural world? Biological kinds are very salient to people of all ages, and for this reason, a better understanding of categorization is a goal ethnobiologists and cognitive scientists share. The purposes of such studies are varied, but they provide insight into how cognitive abilities may develop over time as children grow and gain more experience with the world (Carey 1985; Johnson and Mervis 1997). Researchers are interested in universals of human cognition and culturally driven variability. Emphasis in this body of research is on observable differences in the ways novices and experts think about and identify natural kinds and less on the process of learning itself, typically using experimental research designs common in psychology.

Categorization and classification research also explores the ways knowledge about behavior, utility, and other background information contributes to categorization priorities, in relation to perceptual and morphological features (Berlin 1992; Boster 1987; Johnson and Mervis 1998; Medin et al. 1997; Nolan 2002). A key question that such researchers ask is: “Does categorical knowledge change as a function of domain expertise?” In order to address this question, researchers have investigated categorization of a variety of natural kinds, including fish, trees, and birds, by novices and experts as well as individuals from different cultural groups (Medin and Atran 1999; Medin et al. 1997, 2006; Waxman et al. 2007). Reasoning about natural kinds is directly affected by cultural beliefs and change or loss of ethnobiological knowledge is observable in the ways children make inductive generalizations about natural kinds in rural and urban areas of the United States as well as across cultural groups—what Atran and Medin (2008) term “devolution” of knowledge. Although this body of research contributes to our understanding of the biological and cultural aspects of environmental cognition, the experimental designs often isolate knowledge from the cultural and ecological contexts in which it is used.

In addition to the explicitly ethnobiological research already described, a handful of studies carried out within other research traditions (including cultural anthropology, education, and ecology) attend to the process of learning, transmission, and acquisition. A central concern of such studies is how cultural knowledge and skills are transferred: whether it occurs primarily *between* individuals of the same generation or from one generation to the next, and how this affects cultural continuity and change over time (Hewlett and Cavalli-Sforza 1986). Foremost among these is an early study by education researchers Ruddle and Chesterfield (1977) about how children acquire subsistence skills and strategies in the Orinoco Delta in Venezuela. They document how children learn skills directly from parents in an apprenticeship fashion. Two other important studies that approached the topic with the aim of understanding how skills are distributed include Hewlett and Cavalli-Sforza’s (1986) research with the Aka in Africa, which tracks a set of skills across age groups, and Ohmagari and Berkes’s (1997) study of the distribution of Cree women’s bush skills. Both of these studies quantify the process of cultural transmission to document individual knowledge of particular tasks. These studies do not attend to the distribution of knowledge between social groups, but do emphasize the practice of skills by individuals of different ages. As we will see, the focus on the “skills” portion of environmental knowledge does capture a vital aspect of how such knowledge is practiced and shared, which is a key contribution.

This brief overview of the history of studies of learning ethnobiological knowledge and skills illustrates the need for interdisciplinary training in order to begin to build theory and method that will allow us to better understand this lifelong process. In addition, process-oriented studies would not be possible without time-tested methods and theories from the work of the ethnobiologists who pioneered the discipline. This is an illustration of the importance of continuing to develop rigorous methods and build upon previous scholarship. Zent sums up a current trend in ethnobiology as he describes a shift “of descriptive and explanatory focus from structure, classification, function, and content to process, genesis, variation, and context” (Zent 2009: 48). Turning our attention to the process of learning (as well as changes in) ethnobiological knowledge also reflects a contemporaneous emphasis on fluidity and continual change in the associated discipline of anthropology (Knauff 2006). Education in all its forms, is obviously a critical component of this emphasis, but research attempting to describe and analyze ephemeral instances of “learning-in-context” is only just beginning to gain acceptance and momentum of explanatory power.

WORK, PLAY, LEARN: GAINING EXPERTISE WITH THE NONHUMAN WORLD

In my research in southern Belize with Q'eqchi' Maya families over the last decade, I have documented how children learn about their local environment, how environmental knowledge varies by age, gender, and other social categories of difference, and what I refer to as “learning networks,” which describe linkages between “teachers” and “learners” of environmental knowledge. One aspect of that work focused on how parents perceive the learning process. I asked 85 men and women (representing nearly every household in the study community) how their children learned about local plants, animals, and subsistence practices. In Q'eqchi', to ask this question properly, I learned that you needed to use the verb “to work” (*k'anhelak*), not just the verb “to learn” (*tz'olok*), which is associated with formal learning in school. In Q'eqchi', Maya parents talked about their children “learning how to work” as synonymous with learning about the environment. Children learned on the way to the family farm, by helping adults with chores, and by completing tasks specific to their age and gender. That is, they learned by doing, by *working*, not by sitting in a classroom. This reported information was confirmed by my behavioral data collection and participant observation with groups of children as they went about their daily activities (Zarger 2002a,b, 2010).

Researchers agree with the Maya parents I interviewed: outside of formal school, children around the globe learn primarily through participation, observation, and imitation (Gaskins 1999; Greenfield et al 2000; Ingold 2000; Lave and Wenger 1991; MacDonald 2007; Rogoff 2003). Experiential learning takes place in the production of daily life, as siblings, cousins, parents, grandparents, and peers serve as “teachers,” mentors, playmates, and collaborators. In this way, every aspect of life—institutions, local ecologies, identities, language, access to resources, beliefs—shapes the process of learning ethnobiology.

Another way of putting this is that “one learns with one’s entire being—hands and legs, emotions and cognitions, ears and eyes” (Anderson 2011). Just how structured or unstructured these activities are varies from one cultural community to the next and also depends on the type of knowledge and skills being learned (Lancy 2008: 251; Zarger 2002a). This applies to many aspects of daily life, particularly outside-of-school (“informal”) learning—which is where the majority of environmental knowledge acquisition takes place. What we learn and the way we learn it are shaped by cultural context, but through a process Barbara Rogoff calls “guided participation in cultural activities”; direct and indirect skill-building takes place as children around the world participate in the activities, institutions, and discourse of daily life (Rogoff 2003: 283–284). Ethnobiology can benefit from these insights from cross-cultural child development and psychological anthropology, in which researchers have carefully studied cultural contexts of socialization, child-rearing, and cognitive development. Environmental knowledge and practice is not necessarily the focus of this body of work, however. How can this body of research be applied to learning ethnobiology?

Tim Ingold (2000, 2003) provides one of most well thought out and cogent arguments with regards to learning about the natural world. Contrary to the way “transmission” of environmental knowledge has previously been approached, Ingold suggests that one learns the environment by growing up in it, not by receiving information that has been directly transmitted from one generation to the next. He explains that “personal powers of perception and action are developed through the immediate experience of sensory participation with human and nonhuman components of the dwelt-in world” (Ingold 2003:

310). Ingold emphasizes the importance of individual experience, while Lancy recognizes the importance of adult expectations and work in structuring the ways children learn (2008). In what Lancy terms the “chore curriculum,” children are expected to contribute tasks appropriate to their age and ability to their households (Lancy 2008: 235). Whether learning to herd goats, harvest beans, or making fishhooks, children cross-culturally gain expertise by participating in daily work activities, often engaging in different types of play along the way (Lancy 1996, 2008; Tucker and Young 2005; Zarger 2002a). My own research suggests that adult work informs children’s environmental knowledge acquisition, but the individual experiences children gain from immersion in a local landscape—Ingold’s “dwelt-in world”—is also a complementary and necessary component. Formal instruction is relatively rare for these kinds of skills (Lancy 2008: 241).

However, specialized tasks such as using certain medicinal plants or harvesting plant materials that require great skill or strength (such as palm hearts) tend to be mastered later in life and require learning through apprenticeship (Vermonden 2009; Zent 2009). Although mastery of specialized knowledge may take place in the late teens or early twenties, or even later in life, Vermonden (2009) astutely observes that individuals begin the learning process during childhood and continue to add layer upon layer of expertise as they age and participate in activities over the years. Archaeologists have studied novices and experts in the production of material culture, emphasizing the importance of apprenticeship as young artisans work on one side of a ceramic pot while their “master” teacher works on the other side (Crown 2002). This contrasts with how children learn generalized subsistence skills that are widely distributed, but resonates with descriptions of young girls learning to weave in Zinacantan, highland Mexico (Greenfield et al. 2000). It is important to note that learning through apprenticeship and learning-by-doing individually or with peers (but without explicit instruction) are not mutually exclusive. It appears that different skill sets may require different learning modalities (Zarger 2002a). In this way, studying the ways ethnobiology is learned across the lifespan, from infancy to old age, is perhaps the most effective approach to capturing its complexity. In the next section I focus on three case studies to apply some of these general principals of learning outside of school explicitly to ethnobiological research.

KEY INSIGHTS ON LEARNING ETHNOBIOLOGY

Research on the learning, transmission, and acquisition of environmental knowledge and skills has expanded rapidly over the last decade, but it can be considered a newly emergent topic within the larger field of ethnobiology. Theory and methods are being developed by various researchers somewhat independently and more integration of both will allow a better understanding of how children’s learning experiences vary cross-culturally and which aspects appear to be found in most cultural contexts (including industrialized settings). With that said, there are some generalizations that can be made based on the existing literature, which is heavily biased towards farming societies negotiating globalization. I focus on one of the primary concerns of research to date, the ages at which children develop expertise and variation in knowledge of individuals of different ages.

Age and Development of Expertise

Learning about the natural world occurs very early in life, with language acquisition, as fruits and vegetables are brought into the household, and as infants accompany their mothers

during work activities (Stross 1973). In my research, I suggest that a key transition in the development of expertise occurs between the ages of five and nine years, which corresponds with a developmental shift described by psychologists and the play/work continuum described by Rogoff (1975) (Zarger 2002b, 2010). This represents the time at which children in agrarian economies are quickly integrated into the family's work activities. This shift has not been the focus in most other studies, which have tended to select interviewees from the ages of 8 to 10 or above, so more work can be done to confirm the generalizability of this pattern. Most researchers agree that the majority of generalized (non-specialist) knowledge is acquired by the end of middle childhood, between the ages of 10 to 12 (Hewlett and Cavalli-Sforza 1986; Hunn 2002, 2008; Katz 2004; Stross 1973; Zarger 2002a,b; Zarger and Stepp 2004; Zent 2001; Zent and Zent 2004). In my research with Q'eqchi' Maya children and adults, I found that, when interviewed about plants growing in their homegardens and around their houses, children can identify on average 85% of plants correctly by the age of nine (Zarger 2002b). However, there does appear to be some variation with regards to the age at which individual children's knowledge is comparable to that of adults in the same community. I highlight two studies in the discussion below to illustrate the variability in what ethnobiologists have discovered about when children gain expertise similar to adults.

In their research with Hoti communities in Venezuela, Stanford and Egleé Zent (2004) document variation and change in botanical knowledge across the lifespan and the effects of recent transitions to globalized market economies, formal schooling, and increased sedentism. They interviewed 10–15 men and women in four distinct Hoti communities by creating 1 hectare primary forest plots for each village and tagging large trees and lianas, then asking respondents to identify names and uses for tagged species. In three of the four communities, by the ages of eight to nine children could identify between 40% and 50% of species at the generic level, and by ages 18–19 their knowledge peaks between 70% and 85%, similar to older individuals interviewed (Stanford and Zent 2004: 54). The cultural competence scores, generated with cultural consensus analysis, were analyzed using regression analysis to understand the relationship between age and botanical knowledge. In Cano Mosquito, which is the most remote and reliant on hunting and gathering, there is little difference between the 10–11-year-olds who were the youngest interviewed, and the rest of the adult population. The authors speculate that this may be because children in that community have “more intensive direct contact and interaction with forest biota at an earlier age (Stanford and Zent 2004: 57).” They propose that the process of learning local flora may be somewhat delayed until adolescence in the other three communities in their study, which were more recently sedentary (2004: 57). This suggests that migration may have a significant impact on the process, and that time spent in a particular locality by more than one generation might be critical to building expertise.

In another case study, Felice Wyndham carried out research on children's wild plant knowledge and how formal schooling, bilingualism, and social ties shape that knowledge, with the Rarámuri in the Sierra Tarahumara, Mexico. Wyndham (2010) also finds a complex pattern with regards to the relationship between age and ability to “correctly” identify wild plants. Over a period of 10 months, 106 children were interviewed using 40 dried specimens in a “traveling herbarium,” to assess their ability to name the plants and uses (multiple uses were accounted for in the design). Although there was a weak association between age and naming ability, it accounted for only 11% of the variation in the sample. Age was not significantly tied to interviewees' knowledge of plant uses. As Wyndham notes, this finding was surprising given the fact that other similar studies found a more pronounced association

between age and correct plant-naming scores (Wyndham 2010: 95). The complexity of the learning process is revealed, however, in Wyndham's explanation for this pattern. She cites several interpretations of these results. First is the fact that children today may know less than children of previous generations—entirely plausible, but not the entire story (2010: 96). Another possibility is that knowledge of wild plant names is relatively unimportant in Rarámuri daily life, while knowledge of uses is widespread. The final explanation is most relevant here: that individual experiences with family members who place importance on learning wild plants and “extended time in local landscapes” influence plant learning most fundamentally—more so than age.

Part of this variation may be a result of which types of botanical knowledge are being measured across studies. One study measures wild plant knowledge using dried specimens (Wyndham 2010), another measures knowledge of trees and lianas in forest plots (Zent and Zent 2004), while a third (my research in Belize with Q'eqchi' children and adults discussed previously) measures knowledge of cultivated, semi-cultivated, and wild plants through homegarden interviews and a plant trail (Zarger 2002a). All three of these studies use different methods to assess and measure botanical knowledge and skills, and findings differ in important ways. However, there is remarkable convergence in what researchers have observed. Although age and developmental abilities may be a factor in how children learn local flora, individual experience in the “dwelt-in world” varies from one cultural context to another. Competencies and expertise are ultimately linked to those activities which are valued in a child's community, and children's knowledge is a direct reflection of adult conceptualizations and distribution of knowledge throughout the community. In more recently settled communities, adult knowledge may not differ so much from young people's knowledge, while in other communities there may be noticeable “generation gaps” between elders who have extensive knowledge and youth who have clearly focused on other types of competencies in lieu of learning local flora and fauna. In part, the findings with regards to children's acquisition or development of expertise are relative to adults in the same community—essentially a changing “baseline” from one study to the next. Thus, it is important to note that knowledge and practice is in flux, changing in response to processes often glossed over as “globalization.” It is this dynamism that makes the area of research so intriguing, and yet so difficult to study.

The majority of the research on ethnobiological knowledge with children has been carried out in subsistence farming societies (Reyes-Garcia et al. 2007b). However, there are some exceptions to this generalization, with a small number of studies in hunter-gatherer societies (see Bock and Johnson 2004; Tucker and Young 2005; Zent and Zent 2004). We know that children in foraging communities tend to learn through observation with little formal instruction (MacDonald 2007); that gender roles shape environmental knowledge and skills (Bock and Johnson 2004); and that play and work are intertwined (Tucker and Young 2005), similarly to children in other economies that are primarily subsistence-based. So far, researchers have not attempted to sort out differences in socialization for environmental knowledge and skills between groups with different subsistence patterns. Barry et al. (1959), based on cross-cultural datasets, proposed that socialization patterns depend on subsistence practices. One follow-up study by Hendrix (1985) re-examines the initial data, arguing that gender roles related to subsistence actually have a significant impact on socialization. Another study by Welch (1980) suggests that local ecology may have a greater influence on learning than subsistence. These findings have not been addressed in ethnobiological research, and discovering the ways ecological *and* cultural settings shape the learning process is a productive area for future research.

METHODS FOR DOCUMENTING THE PROCESS OF LEARNING ETHNOBIOLOGICAL KNOWLEDGE AND SKILLS

Conducting research about a dynamic process—in this case learning about the nonhuman world and our roles in it—is not an easy undertaking. In fact, when I first posed the idea for my dissertation research to one of my committee members, I was told, “there’s no way you can study that!” There was a grain of truth in that comment, and probably a dose of realism, but I forged ahead anyway (not usually recommended; always listen to your elders!). Eventually I convinced that senior scholar that it was indeed possible, and as more ethnobiologists have become interested in cultural transmission, acquisition, and change in environmental knowledge, quite an array of methods have been developed for these types of studies. As explained earlier, many tools originally used to document knowledge variation are being applied to explore the variation of knowledge among individuals of different ages, years of formal education, geographic location, and other social categories of difference.

Although providing an exhaustive discussion of methods for studying how ethnobiological knowledge and skills are learned during childhood is beyond the scope of this chapter, there are a wide range of tools that researchers have used; the most commonly used are summarized here. The majority of research has been in the area of ethnobotany, focused more on knowledge variation than the activities of learners (and teachers) themselves. The type of methods commonly used reflect a long-standing interest in eliciting knowledge conceptualized as being “in people’s heads” (a legacy of ethnoscientific notions of culture). For this reason, researchers have begun to acknowledge the need to design studies that emphasize behavioral *and* cognitive data collection. Zent used forest plots in his research with Piarao in Venezuela, in which interviewees identify live specimens, which is helpful in maintaining *in situ* ecological accuracy (Zent 1999). Reyes-Garcia and colleagues employed freelisting of widely used plants and used cultural consensus analysis to measure expertise among individuals (Reyes-Garcia et al. 2007b; Romney et al. 1986). Godoy et al. (2009) develop an approach to resolving what they term the “cohort effect” in which individuals of differing ages are interviewed, and their knowledge of plant names or uses is compared as a proxy for measuring change in knowledge over time. This is indeed a weakness with many study designs, but it is very difficult to overcome without long-term research with particular groups, such as the TAPS panel study described earlier.

One of the few studies to determine whether knowledge loss has taken place, which uses data collected at two different time periods, is a short study I carried out with Richard Stepp in Chiapas, Mexico which relied upon a “plant trail” method. We had the benefit of data collected three decades earlier by Brian Stross (1969), and replicated the study with a representative sample of plants that were tagged along existing trails in the study community. Children ages 5–14 walked the trail with us and we asked them the names and uses of each tagged plant (Zarger and Stepp 2004). Remarkably, we found that children’s plant-naming abilities had changed relatively little since the original study was carried out. The plant trail is a fairly popular method (Collins 2001; Hunn 2008; Zarger 2002a) because it allows individuals to interact with the plants in a naturalistic way, as they are able to see them growing in context—for example crushing the leaves and smelling them. Some challenges with this method are the amount of time necessary to set up the “trail,” culturally significant or useful plants that go “walking” home with someone who happens by, and seasonal variation such as wet and dry seasons, or drastic weather events that all might affect the plants already designated on the trail before all of the data are collected (Collins

2001; Hunn 2008; Zarger 2002a). It may also be challenging to reduce botanical knowledge to a “yes/no” format to quantify it, when there may be multiple names for the same biological species in one research community (Collins 2001).

Another method commonly used to measure individual variation in botanical knowledge, and then compare across age groups or other social variables, is to use dried plant specimens in a “traveling herbarium,” as Felice Wyndham (2010) does in her research in the Sierra Tarahumara with Rarámuri children. This technique allows more control from one interview to the next, and can be carried anywhere. One drawback is that sometimes it may be difficult for children to identify some dried specimens when they may have no trouble if presented with the plant itself. However, this is typically an effective method where it is used.

In an effort to link activity with knowledge, I developed a method for my own research that I called “child-guided interviews.” I carried these out in order to create inventories of homegardens and to measure knowledge variation among siblings within one household (Zarger 2002b). This was helpful in understanding how children learned plants growing in their immediate vicinity and to document which plants the youngest children tended to learn first. Children were usually thrilled to lead me around their homegardens and display their extensive knowledge of most of the plants growing there. In my research I also used pile sorts—a technique that works well with children—they often see it as a type of game. It is less fun for the researcher who has to tediously record which cards are sorted into the same piles over and over again, but I found it to be a powerful method for understanding differences between adult and child conceptualizations of the living world (when combined with consensus analysis and multidimensional scaling using *Anthropac* (Borgatti 1996)) and how cultural uses intersect with biological salience of morphology (Zarger 2002a). Another technique that could be used more often in ethnobiological research is systematic behavioral observation (Johnson and Sackett 1998), which includes time allocation studies, spot observations, and focal follows of individuals. These types of behavioral measures can be contrasted with cognitive tools for collecting data and triangulated to better contextualize knowledge with how it is actually used on a daily basis. For research that focuses on children, ethnographically grounded participant observation may ultimately be the best tool for understanding the learning process from the perspective of the children themselves (Katz 2004; Zarger 2010).

Zent (2009: 49) suggests that an important trend in studies that attempt to capture the fluidity of environmental knowledge is a concerted effort to develop more robust quantitative measures so that greater comparability across studies is possible, leading to more rich theoretical developments in the field. In addition, he observes that diachronic studies and better understanding of what affects knowledge variation (in other words, defining the “baseline”) is necessary (Zent 2009: 48). Reyes-Garcia et al. (2007b: 196) also made this observation in their review of studies of ethnobotanical knowledge variation. They observe that ethnobotanists measure individual variations in botanical knowledge in widely differing ways and they should be certain whether their methods capture all dimensions of that knowledge by using a variety of methods in a given study. In addition, Reyes-Garcia and co-authors implore researchers to create a distinction between “practical” knowledge (skills) and “theoretical” knowledge (reported knowledge), acknowledging the important role that behavior plays in environmental knowledge (Reyes-Garcia et al. 2007a). However, in most studies, the behavioral component is solely *reported* in terms of abilities to complete a task. Incorporating systematic behavioral observation would augment existing research so as to better understand learning processes in addition to reported knowledge and skills.

ETHNOBIOLOGY INSIDE AND OUT: APPLYING WHAT WE KNOW

One of the assumptions that underlie much current research in ethnobiology is that environmental knowledge is now being lost at a rapid rate—constituting a hemorrhaging of expertise accumulated over millennia (Zent 2009). A recent UNESCO report (UNESCO 2009) expresses great interest in the possibility of large-scale loss of environmental knowledge. Combine this with concerns over the lack of time children spend in “nature,” particularly those in industrialized settings—what Richard Louv (2005) terms “nature deficit disorder”—and a real crisis emerges.

The reality is likely both more and less urgent than this assumption suggests. In a study of children’s plant-naming ability in Chiapas, we found that there had been little significant change over a period of 30 years despite drastic changes in infrastructure and economy, not to mention armed conflict (Zarger and Stepp 2004). Although surprised by the results of the study at first, upon further reflection, we realized that children’s daily activities had changed relatively little in that community. Godoy et al. (2009) also found that Tsimane’ environmental knowledge is not declining. In contrast with these results, most other studies have documented knowledge loss in the face of greater mobility, sedentism, change in subsistence patterns, and other impacts of globalization (Nabhan and St. Antoine 1993; Ross 2002; Zent 2001; Zent and Zent 2004). More research needs to be carried out on this question in particular. A critical aspect of this issue is to understand how formal schooling affects environmental knowledge and skills. Are children who spend more time in school (increasingly the norm for children around the world today) less likely to learn about the nonhuman world? This was an assumption of early research into traditional ecological knowledge, without much in the way of evidence to support it other than anecdotal evidence and awareness that ways of life were changing quickly. Now, there have been several studies that address this topic specifically. What they have found is: it depends!

Researchers have measured the impact of formal school on environmental knowledge in varying ways. Several studies report that schooling does appear to have a negative impact on environmental knowledge (in some studies, more strongly than others) (Quinlan and Quinlan 2007; Wyndham 2010; Zent 2001). Interestingly, there are others that find little relationship between formal school and environmental knowledge (Godoy et al. 2009; Guest 2002; Zarger 2002a) or actually find a positive relationship (Ruiz-Mallen 2009). Reyes-Garcia et al. (2010) found that the slightly negative impact of formal schooling on Tsimane’ environmental knowledge may have been mitigated by the inclusion of environmental knowledge in the curriculum. I have echoed this call in my own work (Zarger 2002a) and I am working with collaborators and educators in Belize on curricula for primary schools that link cultural and environmental “heritage” incorporating ethnobiological topics. Thus far, the inclusion of experiential learning activities and local environmental knowledge in the pilot program has been successful in emphasizing the value of that knowledge to children who may not be engaged in learning in the same way as previous generations. Zent and Zent (2004) also provide some concrete suggestions about ways to support environmental knowledge acquisition: programs should be offered as early in formal school as possible, in elementary school (2004: 70). Evidence that the development of expertise occurs rapidly between the ages of five and nine lends more support for this idea (Zarger 2002a, 2010). Ultimately, the verdict is still out on how schooling may influence environmental knowledge, but there is some indication that there are innovative ways being developed to alleviate this conflict where it does indeed exist (Maffi and Woodley 2010).

Learning ethnobiology, as is evident through the discussion in this chapter, cannot ultimately take place in a classroom. Particular lived-in places lie at the heart of the process. There are some additional aspects of the process that should be taken into account in the design and implementation of education, revitalization, and heritage initiatives aimed at supporting the continuity of environmental knowledge. For example, early to middle childhood are critical time periods for acquisition, and peer learning may be just as important as transmission from generation to generation. We need to know more about how to translate research findings into successful programs; working collaboratively with individuals and communities who share knowledge and skills, young and old, on their terms, is essential. Efforts to sustain ethnobiological knowledge may not be successful unless we attend to the ways in which each generation encounters the living world and continually adapts in the face of change.

REFERENCES

- ALEXIADES M. The cultural and economic globalisation of traditional environmental knowledge systems. In: HECKLER S, editor. *Landscape, process, and power: re-evaluating traditional environmental knowledge*. Studies in environmental anthropology and ethnobiology. Oxford: Bergham Books; 2009. p 68–98.
- ANDERSON E. Drawing from traditional and “indigenous” socioecological theories. In: KOPNINA H, SHOREMAN-OUMET E, editors. *Environmental anthropology: cross-disciplinary investigations*. Routledge; 2011.
- ATRAN S. Cognitive foundations of natural history: towards an anthropology of science. Cambridge: Cambridge University Press; 1990.
- ATRAN S, MEDIN D, ROSS N. Evolution and devolution of knowledge: a tale of two biologies. *J Roy Anthropol Inst* 2004;10(2):395–420.
- ATRAN S, MEDIN DL. The native mind and the cultural construction of nature. Cambridge (MA): MIT Press; 2008.
- BARRY III H, CHILD IL, BACON MK. Relation of Child Training to Subsistence Economy. *American Anthropologist* 1959;61:51–63.
- BATESON G. *Naven: a survey of the problems suggested by a composite picture of the culture of a New Guinea tribe drawn from three points of view*. Stanford (CA): Stanford University Press; 1936.
- BERLIN B. *Ethnobiological classification: principles of categorization of plants and animals in traditional societies*. Princeton (NJ): Princeton University Press; 1992.
- BERLIN B, BREEDLOVE DE, RAVEN PH. *Principles of Tzeltal plant classification; an introduction to the botanical ethnography of a Mayan-speaking people of Highland Chiapas*. New York: Academic Press; 1974.
- BICKER A, SILLITOE P, POTTIER J, editors. *Investigating local knowledge: new directions, new approaches*. Burlington (VT): Ashgate; 2004.
- BOCK J, JOHNSON SE. Play and subsistence ecology among the Okavango Delta peoples of Botswana. *Hum Nat* 2004;15(1):63–82.
- BORGATTI SP. *ANTHROPAC 4.0*. Natick (MA): Analytic Technologies; 1996.
- BOSTER J. Exchange of varieties and information between Aguaruna manioc cultivators. *Amer Anthropol* 1986; 88(2):428–436.
- BOSTER J. Agreement between Biological classification systems is not dependent on cultural transmission. *Amer Anthropol* 1987;89(4):914–920.
- BOSTER J. Human Cognition as a Product and Agent of Evolution. In: ELLEN R, FUKUI K, editors. *Redefining nature: ecology, culture, and domestication*. Berg: Oxford; 1996. p 269–290.
- CAREY S. *Conceptual change in childhood*. Cambridge (MA): MIT Press; 1985.
- CHIPENIUK R. Childhood foraging as a means of acquiring competent human cognition about biodiversity. *Environ Behav* 1995;27(4):490–512.
- COLEY JD, ET AL. Inductive reasoning in folkbiological thought. In: MEDIN DL, ATRAN, S, editors. *Folkbiology*. Cambridge (MA): MIT Press; 1999. p 205–232.
- COLLINS D. *From woods to weeds: cultural and ecological transformations in Alta Verapaz, Guatemala* [dissertation]. New Orleans (LA): Tulane University; 2001.
- CONKLIN HC. An ethnoecological approach to shifting agriculture. In: VAYDA AP, editor. *Environment and cultural behavior: ecological studies in cultural anthropology*. American Museum sourcebooks in anthropology. Garden City (NY): The Natural History Press; 1969. p 221–233.
- CROWN PL. Learning and teaching in the Prehispanic American southwest. In: KAMP KA, editor. *Children in the prehistoric Puebloan southwest*. Salt Lake City (UT): University of Utah Press; 2002. p 108–124.
- CRUZ GARCIA G. The mother–child nexus. Knowledge and valuation of wild food plants in Wayanad, Western Ghats, India. *J Ethnobiol Ethnomed* 2006;2(1):39.
- DOUGHERTY JWD. Learning names for plants and plants for names. *Anthrop Linguist* 1979;21:298–315.
- ELLEN R, HARRIS H. Introduction: indigenous environmental knowledge and its transformations. In: ELLEN PPR, BICKER A, editors. *Indigenous environmental knowledge and its transformations: critical anthropological perspectives*.

- Studies in environmental anthropology. Amsterdam: Harwood Academic Publishers; 2000. p 1–34.
- FORTES M. WITH INTERNATIONAL AFRICAN INSTITUTE. Social and psychological aspects of education in Taleland. London: Oxford University Press for the International Institute of African Languages and Cultures; 1938.
- GASKINS S. Children's daily lives in a Mayan village: a case study of culturally constructed roles and activities. In: GÖNCÜ A, editor. Children's engagement in the world: sociocultural perspectives. Cambridge: Cambridge University Press; 1999. p 25–61.
- GODOY R, ET AL. Long-term (secular) change of ethnobotanical knowledge of useful plants. separating cohort and age effects. *J Anthropol Res* 2009;65(1):51–67.
- GREENFIELD PM, MAYNARD AE, CHILDS CP. History, culture, learning, and development. *Cross-Cult Res* 2000; 34(4):351–374.
- GUEST G. Market integration and the distribution of ecological knowledge within an Ecuadorian fishing community. *J Ecol Anthropol* 2002;6:38–49.
- HECKLER S. Introduction. In: HECKLER S, editor. Landscape, process, and power: re-evaluating traditional environmental knowledge. Studies in environmental anthropology and ethnobiology. Oxford: Berghan Books; 2009. p 1–18.
- HENDRIX L. Economy and child training reexamined. *Ethos* 1985;3(3):246–261.
- HEWLETT BS, CAVALLI-SFORZA LL. Cultural transmission among Aka Pygmies. *Amer Anthropol* 1986;88:922–934.
- HOWARD PL, editor. Women and plants: gender relations in biodiversity management and conservation. London and New York: Zed Press, and Palgrave Macmillan; 2003.
- HUNN ES. A Zapotec natural history: trees, herbs, and flowers, birds, beasts, and bugs in the life of San Juan Gbëë Tuscon: University of Arizona Press; 2008.
- HUNN ES. Tzeltal folk zoology: the classification of discontinuities in nature. New York: Academic Press; 1977.
- HUNN E. Evidence for the precocious acquisition of plant knowledge by Zapotec children. In: STEPP JR, WYNDHAM FS, ZARGER RK, editors. Ethnobiology and biocultural diversity. Athens: University of Georgia Press; 2002.
- HUNN E. Ethnobiology in four phases. *J Ethnobiol* 2007; 27(1):1–10.
- INGOLD T. The perception of the environment: essays on livelihood, dwelling and skill. London and New York: Routledge; 2000.
- INGOLD T. Two reflections on ecological knowledge. In: SANGA G, ORTALLI G, editors. Nature knowledge: ethno-science, cognition, and utility. Oxford: Berghan Books; 2003. p 301–311.
- JOHNSON A, SACKETT R. Direct systematic observation of behavior. In: BERNARD HR, editor. Handbook of methods in cultural anthropology. Walnut Creek (CA): Altamira Press; 1998. p 301–331.
- JOHNSON KE, MERVIS CB. Effects of varying levels of expertise on the basic level of categorization. *J Exper Psychol* 1997;126(3):248–277.
- JOHNSON KE, MERVIS CB. Impact of intuitive theories of feature recruitment throughout the continuum of expertise. *Mem Cogn* 1998;26(2):382–401.
- KAHN PIT, ET AL. Along the Rio Negro: Brazilian children's environmental views and values. *Dev Psychol* 1996; 32:979–987.
- KATZ C. Herders, gatherers, and foragers: the emerging botanics of children in rural Sudan. *Child Environ Quart* 1989; 6(1):46–53.
- KATZ C. Growing up global: economic restructuring and children's everyday lives. Minneapolis: University of Minnesota Press; 2004.
- KEITH K. Childhood learning and the distribution of knowledge in foraging societies. *Archeol Pap Amer Anthropol Assoc* 2005;15(1):27–40.
- KNAUFT B. Anthropology in the middle. *Anthropol Theory* 2006;6(4):407–430.
- LANCY DF. Playing on the mother-ground: cultural routines for children's development. New York: Guilford Press; 1996.
- LANCY DF. The anthropology of childhood: cherubs, chattel, changelings. Cambridge: Cambridge University Press; 2008.
- LAVE J, WENGER E. Situated learning: legitimate peripheral participation. Cambridge: Cambridge University Press; 1991.
- LOUV R. Last child in the woods: saving our children from nature-deficit disorder. Chapel Hill (NC): Algonquin Books; 2005.
- MACDONALD K. Cross-cultural comparison of learning in human hunting. Implications for life history evolution. *Hum Nat* 2007;18(4).
- MAFFI L, WOODLEY E. Biocultural diversity conservation: a global sourcebook. London: Earthscan; 2010.
- MEAD, M. Coming of age in Samoa: a psychological study of primitive youth for western civilization. New York, NY: American Museum of Natural History; 1928.
- MEDIN DL, ATRAN S, editors. Folkbiology. Cambridge (MA): MIT Press; 1999.
- MEDIN DL, ATRAN S. The native mind: biological categorization and reasoning in development and across cultures. *Psychol Rev* 2004;111(4):960–983.
- MEDIN D, ET AL. Categorization and reasoning among tree experts: do all roads lead to Rome? *Cogn Psychol* 1997;32:49–96.
- MEDIN DL, ET AL. Folkbiology of freshwater fish. *Cognition* 2006;99(3):237–273.
- NABHAN GP, St. ANTOINE S. The loss of floral and faunal story: the extinction of experience. In: KELLERT SR, WILSON EO, editors. The biophilia hypothesis. Washington (DC): Island Press; 1993. p 229–250.
- NOLAN J. Wild plant classification in Little Dixie: variation in a regional culture. *J Ecol Anthropol* 2002;6(1):69–81.
- OHMAGARI K, BERKES F. Transmission of indigenous knowledge and bush skills among the Western James Bay Cree Women of Subarctic Canada. *Hum Ecol* 1997; 25:197–222.

- ORLOVE BS. Ecological anthropology. *Annu Rev Anthropol* 1980;9:235–273.
- PIERONI A, VANDEBROEK I, editors. *Traveling cultures and plants: the ethnobiology and ethnopharmacy of migrations*. Volume 7. Oxford: Berghman Books; 2007.
- QUINLAN MB, QUINLAN RJ. Modernization and medicinal plant knowledge in a Caribbean horticultural village. *Med Anthropol Quart* 2007;21(2):169–192.
- REYES-GARCÍA V, ET AL. Market economy and the loss of folk knowledge of plant uses. *Curr Anthropol* 2005;46: 651–656.
- REYES-GARCÍA V, ET AL. Economic development and local ecological knowledge: a deadlock? Quantitative research from a Native Amazonian society. *Hum Ecol* 2007a;35: 371–377.
- REYES-GARCÍA V, ET AL. Concepts and methods in studies measuring individual ethnobotanical knowledge. *J Ethnobiol* 2007b;27(2):182–203.
- REYES-GARCÍA V, ET AL. Schooling and local environmental knowledge: do they complement or substitute each other? *Int J Educ Dev* 2010;30(3):305–313.
- ROGOFF B. *Apprenticeship in thinking: cognitive development in social context*. Oxford: Oxford University Press; 1990.
- ROGOFF B. *The cultural nature of human development*. Oxford University Press; 2003.
- ROGOFF B, ET AL. Age of assignment of roles and responsibilities to children: a cross-cultural survey. *Hum Devel* 1975;18:353–369.
- ROMNEY AK, WELLER S, BATCHELDER WH. Culture as consensus: a theory of cultural and informant accuracy. *Amer Anthropol* 1986;88(2):313–338.
- ROSS N. Lacandon Maya intergenerational change and the erosion of folk biological knowledge. In: STEPP JR, WYNDHAM FS, ZARGER RK, editors. *Ethnobiology and biocultural diversity*. Athens: University of Georgia Press; 2002; p 585–592.
- ROSS N, ET AL. Cultural and experiential differences in the development of folkbiological induction. *Cogn Devel* 2003;18(1): 25.
- RUDDLE K. The transmission of traditional ecological knowledge. In: INGLIS JT, editor. *Traditional ecological knowledge: concepts and cases*. Ottawa (ON): Canadian Museum of Nature; 1993. p 17–33.
- RUDDLE K, CHESTERFIELD R. *Education for traditional food procurement in the Orinoco Delta*. Volume 53. Publications in Ibero-Americana. Berkeley: University of California Press; 1977.
- RUIZ-MALLEN I, ET AL. School and local environmental knowledge; what are the links? A case study among Indigenous adolescents in Oaxaca, Mexico. *Int Res Geogr Environ Educ* 2009;18(2):82–96.
- SETALAPHRUK C, PRICE L. Children's traditional ecological knowledge of wild food resources: a case study in a rural village in northeast Thailand. *J Ethnobiol Ethnomed* 2007;3(1): 33.
- STROSS B. *Aspects of language acquisition by Tzeltal children* [PhD thesis]. Berkeley: University of California; 1969.
- STROSS B. Acquisition of botanical terminology by Tzeltal children. In: EDMONSON MS, editor. *Meaning in Mayan languages*. The Hague: Mouton; 1973. p 107–141.
- STURTEVANT WC. Studies in ethnoscience. *Amer Anthropol* 1964;66(3):99–131.
- TUCKER B, YOUNG AG. Growing up Mikea: children's time allocation and tuber foraging in southwestern Madagascar. In: HEWLITT BS, LAMB ME, editors. *Hunter-gatherer childhoods: evolutionary, developmental, and cultural perspectives*. New Brunswick (NJ): Aldine Transaction; 2005. p 147–171.
- UNESCO. Learning and knowing in indigenous societies today. In: BATES P, CHIBA M, KUBE S, NAKASHIMA D, editors. Paris: UNESCO; 2009. p 128.
- VERMONDEN D. Reproduction and development of expertise within communities of practice: a case study of fishing activities in South Buton. In: HECKLER, editor. *Landscape, process, and power: re-evaluating traditional environmental knowledge*. Studies in environmental anthropology and ethnobiology. Oxford: Berghman Books; 2009. p 205–229.
- WAXMAN SR. The dubbing ceremony revisited: object naming and categorization in infancy and early childhood. In: MEDIN DL, ATRAN S, editors. *Folkbiology*. Cambridge (MA): MIT Press; 1999. p 233–284.
- WAXMAN S, MEDIN D, ROSS N. Folkbiological reasoning from a cross-cultural developmental perspective: early essentialist notions are shaped by cultural beliefs. *Dev Psychol* 2007;43(2):294–308.
- WELCH MR. Environmental vs. technological effects on childhood socialization processes: a cross-cultural study. *Int J Sociol Fam* 1980;10(Jul–Dec):233–242.
- WHITING BB, WHITING JM. *Children of six cultures: a psycho-cultural analysis*. Cambridge: Harvard University Press; 1975.
- WYNDHAM FS. The transmission of traditional plant knowledge in community contexts: a human ecosystem perspective. In: STEPP JR, WYNDHAM FS, ZARGER RK, editors. *Ethnobiology and biocultural diversity*. Athens: University of Georgia Press; 2002. p 549–559.
- WYNDHAM FS. Environments of learning: Rarámuri children's plant knowledge and experience of schooling, family, and landscapes in the Sierra Tarahumara, Mexico. *Hum Ecol* 2010;38(1):87–99.
- ZARGER RK. Acquisition and transmission of subsistence knowledge by Q'eqchi' Maya in Belize. In: STEPP JR, WYNDHAM FS, ZARGER RK, editors. *Ethnobiology and biocultural diversity*. Athens: University of Georgia Press; 2002a. p 593–603.
- ZARGER RK. Children's ethnoecological knowledge: situated learning and the cultural transmission of subsistence knowledge and skills among Q'eqchi' Maya [dissertation]. Athens: University of Georgia; 2002b.
- ZARGER RK. Learning the environment. In: LANCY D, BOCK J, GASKINS S, editors. *The anthropology of learning in childhood*. Walnut Creek (CA): Altamira Press; 2010. p 341–370.

- ZARGER RK, STEPP JR. Persistence of botanical knowledge among Tzeltal Maya children. *Curr Anthropol* 2004; 45:413–418.
- ZENT S. The quandary of conserving ethnobotanical knowledge: a Piaroa example. In: BLOUNT BG, GRAGSON T, editors. *Ethnoecology: knowledge, resources, rights*. Athens: University of Georgia Press; 1999. p 90–124.
- ZENT S. Acculturation and ethnobotanical knowledge loss among the Piaroa of Venezuela: demonstration of a quantitative method for the empirical study of TEK change. In: MAFFI L, editor. *On biocultural diversity: linking language, knowledge, and the environment*. Washington (DC): Smithsonian Institution Press; 2001. p 190–211.
- ZENT S. A genealogy of scientific representations of indigenous knowledge. In: HECKLER S, editor. *Landscape, process, and power: re-evaluating traditional environmental knowledge*. Studies in environmental anthropology and ethnobiology. Oxford: Berghen Books; 2009. p 19–67.
- ZENT S, ZENT EL. Ethnobotanical convergence, divergence, and change among the Hoti of the Venezuelan Guayana. In: CARLSON TJ, MAFFI L, editors. *Ethnobotany and the conservation of biocultural diversity*. Advances in Economic Botany. Bronx (NY): New York Botanical Garden Press; 2004. p 37–78.

Index

- Abu Hureyra 308
Acanthus (*Acanthus L.*) 366
Accelerator dating methods 17
Acer (Maple) 140, 322, 343, 364
Adansonia digitata (Baobab) 356
Agave (*Agave*) 84, 168, 156, 165, 363
Agouti (*Dasyprocta*) 110
Agreements 35–36, 54–5, 85, 140, 244, 250, 252, 331, 337, 339–40, 343–7
Agriculture 7, 42–3, 59, 89–91, 135–9, 141, 153, 163, 168, 174, 177–84, 190, 206, 222, 253, 254, 264, 299, 301, 305–15, 324
Agroforestry 111, 240, 301
Agroecology 305–315
Sustainable agriculture 89–90, 144, 315
Ainu 262
Allelopathy 239, 289, 301
Aleut 67
Almond (*Prunus dulcis*) 174
Alpaca (*Vicugna pacos*) 308
Amanita muscaria (fly agaric) 194
Amaranth (*Amaranthus*) 89, 108, 152, 156, 162–3
Amaranthus (Amaranth) 89, 108, 152, 156, 162–3
Amazon 19, 32, 59–60, 85, 91, 138–9, 179, 183, 190, 263, 271, 312, 330
American Anthropological Association 31, 305
American ginseng (*Panax quinquefolius*) 244
American Southwest 16, 73, 135, 152–3, 160, 165–8, 180, 260–1 292, 294, 306
Amla (*Phyllanthus emblica*) 245, 341
Anemone (*Anemone L.*) 358
Anemophily 154
Analytic knowledge 9, 116, 119, 134, 337
Ancestral Pueblo 73, 162–6, 292
Ancient DNA 165, 293, 353
Anderson, Edgar 310
Animism 85, 93–4
Antelope, Pronghorn (Antilocapridae) 73
Anthropogenic soils 296
Anthropology 10, 16, 19, 20, 28, 53, 129, 134–5, 138, 141, 165, 183, 196, 204, 216, 219, 233, 271, 286, 307, 313, 336, 343–4, 352, 373, 375–6
Applied 12, 22, 116
Cognitive 5, 19, 116, 135
Cultural 6,7,8, 116
Ecological 6, 8, 307
Environmental 6, 138
Medical 141
Social 7
Antilocapridae (Pronghorn Antelope) 73
Ants (Formicidae) 86–7
Anura (Frog) 84, 110, 345
Apple (*Malus domestica*) 5, 182, 197, 213, 311, 358–9, 364
Apricot (*Prunus armeniaca*) 358
Archaeology 2, 6, 17–20, 106, 115ff., 126, 139, 153, 167, 181, 288, 293, 307
Archaeobotany 2, 6, 16, 167, 176–9
Macro remains 17, 176–9, 183
Micro remains 17
Archaeoethnobotany 6
Archaeoethnobiology 6
Zooarchaeology 2, 6, 18, 97ff., 101, 112, 115ff., 290, 296
Applied zooarchaeology 117
Zooarchaeological Specimen Identification 101
Zooarchaeological Subsistence Interpretation 105
Arctic ground squirrel (*Spermophilus parryi*) 142
Arecaceae (Palms) 84, 106–7, 254, 263, 356
Aristotle 72–3
Armillariella mellea (Honey mushroom) 216
Arrowroot (*Marantha arundinacea*) 180, 183–4
Arroyo Hondo, New Mexico 19, 167
Artemisia (Sagebrush) 68, 154, 164
Arundinaria gigantea (River cane) 140
Arusha 219
Ash wood (*Fraxinus excelsior*) 142
Asperula odorata (Woodruff) 198
Assegai tree (*Curtisia dentate*) 238

- Astronomy 4
- Australia, 3, 36, 72, 183, 222, 306
 Dreamtime 298
 Indigenous Peoples 85, 88, 90, 143, 215, 271–2,
 289, 296–8, 308, 364
- Awajún 262–3
- Aztecs 5, 15, 89, 93, 306–7
 Uto-Aztecan Speakers 306
- Baobab (*Adansonia digitata*) 356
- Bankclimber (*Plectomerus dombeyanus*) 124, 126
- Barley (*Hordeum vulgare*) 176, 183, 311, 360, 363
- Barrows, David 16
- Basketry 16, 184, 236, 290–1, 299
- Basso, Keith 6, 271
- Basswood (*Tilia* sp.) 142
- Bateson, Gregory 374
- Bayh-Dole Act 46
- Bean family (Fabaceae) 70, 89, 108, 135, 141, 150,
 160, 182, 261, 299, 308, 311, 324, 378
- Beargrass (*Nolina*) 160–1
- Bears (*Ursus*) 73, 74, 76, 94, 269, 364
 Black bears (*Ursus americanus*) 119, 121–124
- Bees (Apoidea) 39, 87, 165, 271, 301
- Beetle (Coleoptera) 87, 320
- Beeweed (*Cleome serrulata*) 163, 165–6
- Belmont Report 31
- Benefit Sharing 52, 234
 Access and Benefit Sharing (ABS) 39–41
- Benin 20
- Berlin, Brent 5, 135, 321, 323–4, 327, 329–1
- Bhil 262
- Binomials 17, 86, 321–2, 328–1
- Bioaccumulation 145
- Biocultural
 Diversity 20, 32–6, 40, 46, 53, 56, 61, 144,
 191, 233
 Collective bio-cultural heritage 37, 57
 Conservation 56–7
 Knowledge 31, 53, 57, 232, 268
 Landscapes 40
 Research 233
 Resources 57, 59
- Biology
 Field 4, 18, 22, 193, 315, 324, 330, 378
 Folkbiology 335–8, 343, 345, 247
 Population biology 19, 61, 119, 128,
- Biological diversity 20, 28, 32–3, 36, 38–40, 144,
 287, 292
 Heritage 28
 Patches and patchwork 288, 290
- Biopiracy 9, 32, 39, 45, 53, 138, 205, 234, 237
- Bioprospecting 10, 21, 28, 32
- Bison 75–6, 91–2
- Bitterwort (*Gentiana purpurea*) 193
- Blackberry (*Rubus*) 138, 273
- Blackfeet 74
- Blurton-Jones, Nicholas 87
- Boas, Franz, 6, 11
- Bodhi tree (*Ficus religiosa*) 354
- Boissier, Pierre Edmond 195
- Bolinus brandaris* (Sea mollusk) 366
- Bonn Guidelines 38
- Boswellia papyrifera* (Frankincense) 243
- Brassicaceae (Mustard) 162
- Brazil 235, 363, 366
 Belém 32–3
- British Columbia 66, 142, 272–3, 275–6
see also Northwest Coast
- Brøndegaard, Vagn J. 201, 205
- Brown, Cecil 5, 324–5, 330
- Bulmer, Ralph 10, 18, 85, 206,
- Buffalo Bird Woman, 10
- Burning 91, 166, 175–6, 178–80, 288–90, 292–4,
 199, 301, 306 *see also* Fire
- Cactaceae (Cactus) 152, 320, 327
 Cactus (Cactaceae) 152, 320, 327
- Calendrics 198, 253, 367
 Ritual 294
- Cairina moschata* (Muscovy duck) 308
- Camas (*Camassia quamash*) 150, 306
Camassia quamash (Camas) 150, 306
- Camel (*Camelus*) 87, 90–1, 312
Camelus (Camel) 87, 90–1, 312
- Camellia sinensis* (Tea) 259, 363
- Canadian Institutes for Health Research 31, 250
- Canis lupus* (Dog) 82, 102, 208, 226, 308, 312,
 323, 329
- Cannibalism 89, 163, 217
- Cantharellus cibarius* (Chanterelle) 220, 222
- Capsicum* sp. (Peppers) 138, 252, 324, 363
- Caribbean 3, 91, 368
- Carnation (*Dianthus caryophyllus*) 362–3
- Castanea sativa* (Chestnut) 368
- Castetter, Edward F. 15, 18
- Category-Based Induction (CBI) 342–3
- Cattail (*Typha* L.) 165
- Cavia porcellus* (Guinea pig) 308
- Center for Indigenous Peoples' Nutrition and
 Environment (CINE) 250–3, 255, 260–2
- Ceramics 108, 127, 158, 160, 162, 164, 181–3
- Cervus elaphus* (Elk) 127
- Chaco Canyon 158, 162, 180
- Chagga 221
- Chamorro 147

- Champagne-Aishihik 142
 Chanterelle (*Cantharellus cibarius*) 220, 222
Chenopodium (Pigweed) 156, 161, 252
 Cherokee 18, 139
 Cherry (*Prunus x yedoensis*) 362–3
 Chestnut (*Castanea sativa*) 368
 Cheyenne 74–5
 Chiapas, Mexico 86, 218, 309, 323, 344, 372, 381–2
 Childe, Gordon 308
 China 3, 15, 177, 219, 222, 294, 307–8, 358, 364, 365
 Chinantec 273
 Chocolate (*Theobroma cacao*) 161–2, 195, 324
 Christianity 76
 Chronic Energy Deficiency (CED) 262
 Chrysanthemum (*Chrysanthemum* sp.) 362–3
Chrysanthemum sp. (Chrysanthemum) 362–3
 Clam gardens 296–7
 Clans 54, 73, 364
 Classification systems 3, 4, 5, 15, 17, 45, 216, 270, 275, 338–9, 330, 371
 Ethn classifications 17
 Climate change 69, 119, 264
 Climatology 270
 Cloudberry (*Rubus chaemaemorus*) 198
 Coast Salish 46, 296
 Coconut (*Cocos nucifera*) 143, 368
Cocos nucifera (Coconut) 143, 368
Coffea L. (Coffee) 193, 273, 363
 Coffee (*Coffea* L.) 193, 272, 363
 Cognitive mapping 6–7
 Cognitive process 346–7
 Cognitive science 336, 338, 341, 347, 375
Colocasia (Taro) 179–80
Coleoptera (Beetle) 87, 320
 Colonialism 3, 15–16, 35–36, 53, 90–1, 111
 Comcaàc (Kumkaak, Seri) 277, 291
 Seri 18, 277, 306
 Conservation 2, 28, 46, 56, 58, 71–2, 85, 90–1, 111, 118, 128–9, 137, 138, 140, 232, 235–6, 241–2, 244, 262, 287, 366 *see also* Resource management
 Biology 55–6, 98, 116–8, 133, 137–8, 141
 Environmental protection 20, 30
 Species 20, 30
 Convention 35–6, 53, 56, 148
 UN Convention on Biological Diversity 38–9, 53, 56, 148
 Conklin, Harold 5, 135, 307, 321
 Coppicing 20, 289–1, 299
 Cordyceps (*Cordyceps sinensis*) 217, 226
Cordyceps sinensis (Cordyceps) 217, 226
 Cormorants (Phalacrocoracidae) 93
Corvus 76, 84–5, 94, 191
Corylus avellana (Hazel wood) 142
 Cosmologies 33, 40, 44, 214, 270–1, 274–5
 Cotton (*Gossypium*) 108–9, 161, 164
 Covert categories 324
 Coyote (*Canis latrans*) 323, 327, 329
 Coyote oral traditions 67–9, 77, 84, 93–4
 Cox, Paul Allan 143, 193
 Creator narratives and stories 44, 69, 76–9, 94, 193
 Crop rotation 301
 Crow (*Corvus*) 94
 Crowberry (*Vaccinium vitis-idaea*) 198
 Culinary traditions 87, 155, 160–2, 181–2, 218, 221, 254, 260, 314, 362
 Cultural Consensus Model (CCM) 336–7, 339, 379, 381
 Cultural ecology 6, 10, 133, 268, 376
 Cultural process 336, 346
 Cultural salience 9, 329, 382
Curtisia dentata (Assegai Tree) 237
 Custodianship 286 *see also* Stewardship
 Cycads (*Cycas* spp.) 143, 298, 310
 Cyanobacteria 143
Cyperus papyrus (Papyrus) 362, 366

 Dance 294, 368
 Darwin, Tess 201
Dasyprocta (Agouti) 110
 Date palm (*Phoenix dactylifera*) 353, 355
 Death Valley National Park 299
 De Sahagún, Bernardino 16
 Declarations 35–6, 38, 52, 54
 Declaration of the Rights of Indigenous Peoples 142, 250
 Deforestation 92, 151, 175, 179
 Dendrochronology 129, 205
 Descriptive Relativism 116
 Desert bighorn sheep 299
 De Saussure, Ferdinand 351
 Diabetes 252, 260–2
Dianthus caryophyllus (Carnation) 362–3
 Digging and tilling 20, 178, 241, 289–90, 296–7, 307
 Direct Matrix Ranking (DM)
 Disjunctive populations 291, 293
 Distributive justice 30
 DNA 17–18, 126–7, 163, 240, 353 *see also* Ancient DNA
 Dog (*Canis lupus*) 82, 102, 208, 226, 308, 312, 323, 329
 Dog whelks (*Nucella lapillus*) 128
 The Dogon 85

- Domestication 17, 70, 308, 330, 392
 Animal domestication 18, 70, 127
 Domesticated landscapes 20, 98, 179
 Plant domestication 165–6, 310
- Douglas Fir (*Pseudotsuga*) 165
- Dyes 198, 202, 365–6 *see also* Textiles
- Eastern bluebird (*Sialia sialis*) 320
- Economics 5, 28, 136, 313–4
 Economy and Intellectual Property Rights 41
- Economic resource production 16, 92, 245 *see also*
 Natural resources
- Economic botany 6, 7, 19, 28, 193–5, 215, 305, 336
- Ecology 19, 66, 72, 83, 95, 116–7, 133, 152, 191, 198,
 204–5, 231–4, 269, 271, 293, 376, 380
 Behavioral ecology 121, 124, 179
 Cultural ecology 73, 85, 133
 Forest ecology 299
 Historical ecology 21, 97–8, 129, 140, 179
 Human ecology 85
 Marine ecology 84
 Paleoecology 106, 293–5, 297
 Perceptual ecology 134
 Political ecology 10, 133, 141
 Restoration ecology 116–8, 133
 Sensory ecology 140
- Ecological knowledge 67, 84, 134, 136–137, 138,
 148, 191, 198, 206, 208, 232–6, 231–3, 271,
 278, 280, 286, 294–5, 340, 244, 246, 372,
 375–6, 383–4
- Ecological economics 134
- Ecological factors 19, 239–1, 342
- Ecological functions 19, 214, 240
- Ecological principles 19, 78, 216, 342
- Ecosystems 2, 11, 19, 28, 33, 66, 72, 78, 111, 117, 128,
 138, 141, 227, 233, 241, 263, 268–9, 286, 287,
 293, 294, 298–9, 358
 Agroecosystems 152, 178, 207
 Terrestrial 19, 111, 147 *see also* Landscapes
- Ecotope 270–2, 275, 278–80
- Ecotourism 22, 148
- Egypt 15, 164, 191, 353, 362, 366
- Eidlitz, Kerstin 199
- Elk (*Cervus elaphus*) 127
- Emic analysis 195, 197, 268, 315
- Emslie, Steven, 6
- Enclosures 178, 286, 289, 292, 294
- Environmental education 336, 373
- Environmental knowledge 133, 148, 372–84 *see also*
 Ecological knowledge
- Environmental science 21, 116–7, 128–9
- Ephedra* (Mormon tea) 165
- Equifinality 104–5
- Ethics 17, 19, 294, 299
 Applied 28–30, 55, 144
 Biological 21–2
 Code of ethics 31, 58, 61
 Common morality 29
 Environmental 116, 129, 133
 Principles 30–31, 140
 Ethos 28–29
 Scientific 29, 44, 116–7, 128
- Ethnobiology
 Cognitive 6
 Field 54, 375, 378
- Ethnobotany 1, 6, 8, 15–17, 39, 84, 133ff., 138–9,
 143–4, 191, 194, 197, 198, 201, 204, 206, 314,
 354, 360, 381
 Classifications and nomenclature 17, 325–31
 Interpretive ethnobotany 8, 136
 Participatory ethnobotany 139–40
- Ethno-conchology 17
- Ethnoecology 2, 7, 8, 19–20, 138, 267–80, 312
 Applied 268–9
- Ethnoentomology 32, 83, 85, 87, 208
- Ethnoethology 87
- Ethnoflora Yucatanense* Series, 8
- Ethnography 6, 10, 11, 16, 19, 36, 85, 143, 191–2,
 198, 203, 205, 233, 293, 312, 372
 Interviews 21, 234–6, 292
 The New Ethnography 6, 17, 19
- Ethnoichthyology 83
- Ethnoornithology 83, 85
- Ethnomalacology 83
- Ethnomedicine 21–2, 232–5
- Ethnomycology 194, 207, 213–27
- Ethnopharmacology 21–2, 28, 33, 138, 191, 198, 215
- Ethnoscience 2, 5, 6, 15, 371
- Ethnozoology 2, 6, 15, 17–18, 83–94, 191, 194, 197,
 198, 201, 203, 208
 Classification and nomenclature 17
- Etic analysis 270, 317
- Eurytopic 106
- Extirpation 121–2, 124–6, 193
- Fabaceae (Bean family) 70, 89, 108, 135, 141, 150,
 160, 182, 261, 279, 308, 311, 324, 378
- Falck, Johan Peter 194
- Federación de Comunidades Nativas Maijunas
 (FECONAMAI) 59
- Fennel (*Ferula communis*) 359, 367
- Fenton, Alexander 203
- Fernaldia pandurata* (Loroco) 312
- Fertilizers 89, 215, 240, 288, 291
- Ferula communis* (Fennel) 359, 367
- Ficus religiosa* (Bodhi Tree) 354

- Ficus sycomorus* (Sycomore Fig) 353
Filipendula (Meadowsweet) 181
 Fire 20, 129, 160, 175–6, 181, 206, 273 *see also*
 Burning
 Firestick hunting 297–298
 Fire management 20, 119, 176, 178–80, 240–2,
 288–1, 292–4, 297–9
 Firewood 155, 158, 222, 243, 306, 313
 Fish traps 193, 203, 296–7
 Flotation 17–8, 108, 110, 153–4, 159, 162–3, 184
 Flying fox (*Pteropus*) 147
 Folk-taxonomy 326, 331, 338–9
 Folk biology 190, 203, 205, 326–31, 225–7, 338,
 343, 345, 347
 Folkpsychology 338, 345
 Folk systems 3, 10, 18, 19, 46, 140, 328–32, 338–9,
 371, 374
 Folk science 4, 19, 371
 Foodways 2, 136, 138, 217
 Fore 85–6,
 Forest gardens 179, 300, 311
 Formicidae (Ants) 86–7
 Fortes, Meyer 374
 Frankincense (*Boswellia papyrifera*) 243
Fraxinus excelsior (Ash wood) 146
 Freelisting 198–199, 217, 253, 255, 313, 381
 Fresh water mussels (Unionidae) 124–7
 Frogs (*Anura*) 84, 110, 345
 Fulling, Edmund, 6
 Fungi 199, 213–227, 309
 Mycorrhizal fungi 216, 219, 222
 Parasitic fungi 216
 Saprophytic fungi 216
 Fuchs, Leonhart 192

 Gayfeather (*Liatris punctata*) 167
 Genetics 2, 4, 53, 118–9, 128, 134, 176–7, 238, 240,
 260, 294, 308, 325–6, 353
 Genetic resources 28, 38–41, 53
 Gene banks 40
 Genocide 11
Gentiana purpurea (Bitterwort) 193
 Geochemical analysis 19
 Geographic Information Systems (GIS) 60, 139
 Geomorphology 4
 German linguistics 4, 201, 269
 Gessner, Conrad 192
 Gitksan 272–3, 275–6, 278–79
 Global Strategy for Plant Conservation (GSPC) 56
 Globalization 8, 138, 374–5, 378, 380, 383
 Glottochronology 324–5
 Goody, Jack 198
Gossypium (Cotton) 108–9, 163, 166

 Grape (*Vitis*) 150, 182, 309, 355, 359, 364
 Great Hungarian Plain 190
 Green Revolution 30
 Groote Eylandt 85
 Guarana (*Paullinia cupana*) 363
 Guidelines for Health Research Involving Aboriginal
 People 32
 Guinea pig (*Cavia porcellus*) 308
 Gujar 90
 Guðmundsson, Jón 192, 198

 Hallucinogens 16, 166, 194, 225–6
 Harner, Michael 89
 Harrington, John Peabody 17–18
 Harris, Marvin 89
 Harshberger John 16, 134–5, 148
 Hazel wood (*Corylus avellana*) 142
 Henna (*Lawsonia inermis*) 366
 Herbarium 138, 140, 197, 237, 251, 258, 379, 382
 Herder, Johann 11
 Herodotus 84
 Herring (*Clupea*) 297
 Himalayan snow lotus (*Saussuria laniceps*) 244
 Hinduism 356
 Historic Migrations 141
 HIV/AIDS 232
 Homegardens 206–7, 240, 311, 313–5, 379–80, 382
 Honey Mushroom (*Armillariella mellea*) 216
 Hopf, Ludwig 197
 Hopi 16, 260
Hordeum vulgare (Barley) 174, 183, 311, 360, 363
 Horse (*Equus*) 70, 128, 328, 364
 Horticulture 111, 307, 315
 Houseleek (*Sempervivum tectorum*) 198
 Human coprolites 160, 163, 176
 Hunn, Eugene S. 9, 275, 306, 330
 Hunter-Gatherers 87–88, 129, 166, 177, 305–7, 314,
 330
 Complex Hunter-Fisher-Gatherers 295, 359
 Hydrographic features 270, 272
 Hymenoptera 86–7 *see also* Bees

 Igbo 263
 India 3, 5, 9, 15, 17, 89–90, 183, 255–6, 367
 Indian Ethnobotanical Society 8, 17
 Indigenous
 Archaeology 22
 Conservation 55, 58, 72, 85, 91, 98, 111, 138–139,
 236, 241, 262, 310
 Community knowledge 20–22, 27, 34, 56–8,
 72–3, 76, 140, 234–6, 252, 262, 245
 Compensation 32–4, 39, 52, 56, 58, 252
 Knowledge *see* Traditional knowledge

Indigenous (*Continued*)

- Management 2, 19–20, 58, 98, 111, 130, 142–3, 150, 234, 236, 241, 245, 286–301, 310, 336
- Peoples 3, 10, 19, 35, 44, 52–5, 61, 67, 69, 70–2, 75–6, 91, 139, 143, 147–8, 219, 224–5, 250, 252, 255, 258, 260, 262–4, 287
- Peoples in early ethnobiology 17–19
- Rights 36, 53, 56, 58, 61, 134, 142, 236, 247, 252
- Movements 31, 224
- Worldview 37, 43–4, 46, 67, 77, 133, 135, 241, 286
- Ingano 262
- Intellectual Property Rights 3, 19, 21–2, 28, 31–5, 37, 39–42, 56, 134, 138, 234, 251–2
- Codes of ethics 21
- Misappropriation 39, 56, 58–60
- International Labour Organization 31, 35
- International law 35–44, 274
- International Society of Ethnobiology Code of Ethics 21–22
- Intertidal zones 295–7 *see also* Resource management
- Inujjamiut 85
- Inuit 81, 261–2, 272, 274, 276
- Inupiat 75
- Ipomoea batatas* (Sweet potato) 177–8, 324
- Iris (cf. *Iris missouriensis*) 164, 364
- Iris missouriensis* (Iris) 164, 364
- Iroquois 16, 235
- Irrigation 176, 292, 306, 310
- Islam 238, 355, 359
- Iwigara 75
- Jaguars (*Panthera onca*) 86, 119
- Joensen, Robert 196
- Jones, Volney 17
- Journals
- Journal of Economic Botany 6, 215, 305, 336
- Journal of Ethnobiology 6, 215, 305, 336
- Journal of Ethnobotany 8
- The Milestone 5
- Juniper (*Juniperus*) 119, 162–3, 165–6, 202
- !Kung San Peoples 72, 87–8, 90
- Kalam 85
- Kalm, Peter 194
- Karimojong 89
- Kava kava (*Piper methysticum*) 363
- Kayapó 32, 87, 190, 311
- Keystone species 301
- Kinship 5, 73, 75, 287, 294–5, 288
- Kohistanis 90
- Kolberg, Oskar 196
- Komi 277
- Konner, Melvin 87
- Koyukon 88, 278, 331
- Krebel, Rudolph 195
- Kruuk, Hans 74
- Krzysztof, Kluk 194
- Kumeyaay 150, 306
- Kwäday Dän Ts'inchí 142
- Kwakwaka'wakw 290, 296
- Lakota 75, 77, 78
- Lamiaceae (Mint) 141
- Land tenure 238, 242, 245, 294
- Landscape 6, 7, 267–281 *see also* Domesticated landscapes
- Biophysical landscape 268–71, 274
- Cultural landscapes 268–9, 271–2, 274, 278
- Habitat type 234–5, 269–2, 279
- Landscape degradation 287, 288
- Landscape elements 268–2, 279
- Landscape management 7, 274, 286, 288 (*see* resource management)
- Landscape memory 270, 279–300
- Landscape patterns 98, 242, 245, 268–269
- Landscape structure 243, 268–9
- Sacred landscapes 244, 270, 274–5
- Systems of orientation 275–6
- Viewscape 268
- Latour, Bruno 2
- Laughlin, William S. 84, 87
- Laurel (*Laurus nobilis*) 355, 364
- Laurus nobilis* (Laurel) 355, 364
- Lee, Richard 88
- Leff, Enrique 8
- Lévi-Strauss Claude 2, 92
- Lewis and Clark Expedition 16
- Lexeme 321, 328–9, 331
- Liatris punctata* (Gayfeather) 167
- Lichen 138, 198
- Lightfoot, John 194
- Lilium candidum* (Madonna lily) 361
- Llanos de Mojos 179
- Linguistics 4, 5, 319–332, 372
- Ethnobiology 17, 272, 319–20, 338
- Historical 323
- Identity 33, 54, 144
- Methods 141, 182, 202, 271, 292, 319–20, 324, 337–48
- Linnaeus, Carl 15, 193–4, 320
- Logging 22, 240, 244
- Los Alamos National Laboratory Land Conveyance and Transfer (LC&T) 163
- Lotus (*Nulembo nucifera*) 356–7
- Loroco (*Fernaldia pandurata*) 312

- Maasai 219, 262
 Madonna lily (*Lilium candidum*) 361
 Maidu of California 291
 Maize (*Zea mays*) 5, 89, 108–9, 152, 160–3, 165–7, 174, 179–80, 183, 261, 300–1, 308, 310–4, 324–7, 360
 Malaria 232
Malus domestica (apple) 5, 182, 197, 213, 311, 358–9, 364
 Mandrake (*Mandragora officinarum*) 357
 Manioc (*Manihot esculenta*) 183, 330, 374–5
Manihot esculenta (Manioc) 183, 330, 374–5
 Manninen, Ilmari 199
 Mantegazza, Paolo 195
 Maple (*Acer*) 142, 322, 343, 364
Marantha arundinacea (Arrowroot) 180, 183–4
 Maritime foreshore 296
 Market externalities 30
 Market surveys 205, 236–7, 251
 Marsh rosemary (*Rhododendron tomentosum*)
 Martin, Paul S. 90–1
 Marzell, Heinrich 201
 Mason, Otis 84
 Matrix modeling 243
 Matsutake World Research 222
 Maurizio, Adam 199
 Maya 17, 127, 179–80, 273, 307, 311, 323
 Itza' 338, 341–4
 Lacandon 301
 Q'eqchi' 379–80
 Tzeltal 85, 217, 323–4, 330, 338
 Yucatec 85–6, 301, 310, 313, 315, 337
 Mead, Margaret 374
 Meadowsweet (*Filipendula*) 181
 Medicine 15–6, 19, 88, 134, 136, 138–42, 150, 164, 177, 179, 191, 198, 214, 224–7, 233, 235, 252, 288, 290, 301
 Ethnomedicine 232, 234, 239, 347
 Folk medicine 176, 193–4
 Popular medicine 200–2
 Medin, Douglas 2, 339
 Meru 219
 Mesquite (*Prosopis*) 150, 154, 261, 299–300
 Mesoamerica 3, 5, 150, 163, 179, 223, 308, 324–5, 360
 Mesoscales 118, 128
 Metaphor 66–8, 70, 74, 271, 322, 353, 355, 358, 361, 363
 Micronesia 262, 295
 Middle East 3, 215, 355, 360
 Millet (*Panicum miliaceum*) 89, 182, 308, 311
 Milpa 273, 301, 311, 313
 Minimum Number of Individuals (MNI) 105
 Mint (Lamiaceae) 141
 Missouri Department of Conservation (MDC) 117
 Mobb Deep 84
 Moerman, Daniel 7, 141
 Mongongo (*Schinziophyton rautanenii*) 88
 Monotypic 327–8, 331
 Monte Oscuro Lake 177
 Mormon tea (*Ephedra*) 165
 Mosaic landscape 296
 Mountain goat (*Oreamnos americanus*) 117
 Mountain hemlock (*Tsuga mertensiana*) 142
 Muscovy duck (*Cairina moschata*) 308
 Mussels (Unionidae) 124–6
 Mutually Agreed Terms (MAT) 35, 39, 44
 Mycophobia 215–6, 224
 Mycophilia 215–6, 227
 Mycofiltration 227
 Mycoremediation 297
 Nabhan, Gary Paul 7, 312
Nardostachys grandiflora 243
 National Herbarium of Tanzania 237
 National parks 7, 117
 Natural resources 9, 32, 138, 140, 269–70, 345
 Indigenous ownership of resources 36
 Logging and mining 22
 Wild species 43
 Navajo 16, 85, 90, 272
 Nenets 277
 Netsilik 88
 New Mexico 5, 85, 152, 158, 162–4, 166–7, 292, 294
 New Zealand 36
 Non-Governmental Organizations (NGO) 31, 53, 57
 Nootka Lupine (*Lupinus nootkatensis*) 296
 Northern riceroot lily (*Fritillaria camschatcensis*) 296
 North American Plains groups 70, 289, 306
 Ntlakyapamuk 190
Nucella lapillus (Dog whelks) 128
Nulembo nucifera (Lotus) 356–7
 Number of Identified Specimens (NISIP) 105–6
 Nuaulu 85
 Nuer 85
 Numic
 Comanches 68, 75
 Paiute 68, 277, 306
 Paiute of Nevada 291
 Paiute of Mono Lake and Owens Valley 292, 306
 Shoshone 68, 72, 75
 Timbisha 294, 298–300
 Utes 68
 Nuremburg Doctors Trials 30
 Nuxalk 253, 257, 262
Nymphaea caerulea (Water lily) 357

- Olea europaea* (Olive) 353, 355–6, 364–5
 Olive (*Olea europaea*) 353, 355–6, 364–5
 Olympic National Park, Washington 117
 Onomatopoeic 82, 321
Opuntia spp. (Prickly-pear cactus) 261, 320
 Oral traditions 69–79, 294, 296–8
 Oral stories 20, 84
 Ornithology 5, 85, 203
 Osha (*Ligusticum porteri*) 166
 Osprey (*Pandion haliaetus*) 93
 Ötzi 142
Ovis aries (Sheep) 70, 74, 90, 308, 212, 372
 Ownership
 Familial 296
 Political 294–5
 Religious 294–5
- Pacific Silverweed (*Argentina pacifica*) 296
 Pacific Northwest Coast 45, 70, 73, 76, 142, 152,
 294–6, 306, 331
 Paganism 5, 361, 366
 Palauan 84, 87
 Paleoethnobiology 129, 136, 141–2, 175, 178, 181,
 183–4, 271, 325
 Paleoethnobotany 18, 293 *see also* archaeobotany
 Paleozoology 116–8, 124, 128, 130
 Palm (*Arecaceae*) 84, 108–9, 254, 263, 356
Panax quinquefolius (American ginseng) 244
Panicum miliaceum (Millet) 89, 182, 308, 311
Pandion haliaetus (Osprey) 93
Panthera onca (Jaguar) 86, 119
 Papaya (*Carica papaya*) 324
 Papua New Guinea 6, 85, 89, 177, 215, 323
 Papyrus (*Cyperus papyrus*) 362, 366
 Participant observation 234, 280, 312–3, 382
 Pastoralism 87, 89–90, 139, 307
 Patents 9–10, 42, 45, 56
 Pathan 90
Paullinia cupana (Guarana) 363
 Peach (*Prunus persica*) 353, 365, 358
 Pepper (*Capsicum* sp.) 142, 252, 324, 363
 Permaculture 315
 Pesticides 301
 Peyote (*Lophophora*) 16
Phellinus igniarius 224
 Phenomenology 6, 272
Phoenix dactylifera (Date palm) 353, 355
Phragmites australis (Reedgrass) 167
Phyllanthus emblica (Amla) 245, 341
 Phytochemistry 133, 238, 240
 Phenotypic plasticity 119, 121
 Phytoliths 108, 153, 163, 176–80
 Phytolith analysis 17
- Picea* (Spruce) 142, 180, 322
 Pigweed (*Chenopodium*) 154, 161, 252
 Pinyon (*Pinus*) 299–300
 Pima 18, 85, 190, 260
Piper methysticum (Kava Kava) 363
 Pitre, Giuseppe 196
Plectomerus dombeyanus (Bankclimber) 124, 126
 Pliny de Elder 192
 Pohnpei 262–3
 Polyculture 70
 Pollarding 292
 Pollen grains and analysis 17, 108, 142, 151–7,
 163–5, 175, 295
 Pollen and charcoal analysis 163–4, 167–8, 299
 Pollinators 84, 152, 155, 175, 179, 239, 200
 see also Bees
 Pollution 30, 128, 254, 312
 Pollutant Tributyl Tin (TBT) 128
 Polyculture 70
 Polynesia 177–8, 274, 276, 287, 363
 Polysemy 322
 Polytypic 106, 327–9
 Pomegranate (*Punica granatum*) 353, 359–60, 364
 Ponderosa pine (*Pinus ponderosa*) 165, 291
Portulaca (Purslane) 161
 Positivism 4
 Posey, Darrell A. 32–3, 42, 44
 Postmodernism 8
 Powers, Stephen 16
 Preference Ranking (PM) 236
 Prickly-pear cactus (*Opuntia* spp.) 261, 320
 Prior informed consent (PIC) 34, 39, 45, 52–3
 Procedural knowledge 9
 Project Camelot (Chile) 31
 Protein analysis 19, 127–8, 341
 Pruning 241, 286, 289–90, 299, 306
Prunus armeniaca (Apricot) 358
Prunus dulcis (Almond) 172
Prunus persica (Peach) 353, 365, 358
Prunus spinosa (Sloe plum) 148
Prunus x yedoensis (Japanese Cherry blossom) 362–3
Pseudotsuga (Douglas fir) 167
Psoralea argophylla (Silvery scurfpea) 165
Pteropus (Flying fox) 143
 Pueblo Peoples 18, 159–63, 294
 Laguna Pueblo 73
 Tewa Speaking People 17–18
Punica granatum (Pomeranate) 353, 359–60, 364
 Purslane (*Portulaca*) 161
- Quechua 36
 Quemado Alegre 160
Quercus alba (White oak) 320–2, 327

- Quercus garryana* (Garry oak) 150
 Questionnaires 197–9, 234–5, 256
- Rabbit Drives 299
 Radiocarbon Dating 107, 122, 124, 296
 Radin, Paul 5
 Rea, Amadeo 7, 85
 Rapid Rural Assessment (RRA) 313
 Raramuri 73, 379–80, 382
 Raven (*Corvus*) 76, 84–5, 94, 191
 Red Bow Cliff Dwelling 165
 Reedgrass (*Phragmites australis*) 163
 Reinhold, Kjellman 195
 Renaissance 45, 71, 192, 358, 361
 Replanting 286
 Resource management 2, 9, 17, 19, 32, 137–8, 234–5, 241, 243, 285–301, 336
 Cultural practices 245, 263, 288, 294
 Intertidal resource management 295–7
 Productivity 292
 Technology 20, 30, 182, 288
 Respondants 144, 236, 256, 379
 Ritual 70, 74–8, 83, 89, 166–7, 178, 180, 194, 197, 201, 214–5, 217, 226, 252, 271, 294, 297, 306, 356–7, 359
 Objects 22, 294
 Agriculture 306, 310
 River cane (*Arundinaria gigantea*) 139
 Rhizomes 177, 183–4, 206, 290
 Roberts, Mere 278
 Rock Cree 77, 85
 Roots 88, 94, 143, 153, 158, 164–7, 176–7, 183, 193, 222, 241, 243, 290, 299, 308, 310, 331, 353
 Root gardens 296–7
 Underground storage organs 177, 179, 183, 298
 Rolland, Eugene 201
 Rosaceae (Rose) 141, 164, 362, 366
 Rose (Rosaceae) 141, 164, 362, 366
Rubus chaemaemorus (Cloudberry) 198
Rubus (Blackberry) 138, 273
 Rumphius, Gerog Eberhard 15
- Saami 193, 198, 202, 206
 Saffron (*Crocus sativus*) 184, 365
 Sagebrush (*Artemisia*) 68, 152, 162
 Sahaptin 4, 94, 277, 306, 330–1
 Salmon (*Oncorhynchus*) 88, 142, 272, 297, 306, 328, 365
 Salmon Ritual 70, 76, 94
 Salmon Pueblo 160
 Salmón, E. 22
 Sanders Pierce, Charles 352
 Sauer, Carl 270, 307, 309
- Scales
 Spatial 117–8, 241, 269–70
 Temporal 117–8, 124, 129
 Scientific imperialism 28
 Scientific method 46, 245
 Scientific Revolution 4, 71
 Schefferus, Johannes 152
Schinziophyton rautanenii (Mongongo) 88
 Schultes, Richard 6, 16, 134–5
 Seascape 274, 287
 Seaweed 142
 Sea otters (*Enhydra lutris*) 118, 332
 Sea mollusk (*Bolinus brandaris*) 366
 Seed banks 40, 139, 311
 Selective harvesting 286, 289, 291, 294, 296, 298
 Semantics 2, 330
 Semiology 352
 Seral stages 273
 Seri 18
 Shamanism 93, 194, 217, 219, 224, 227
 Sheep (*Ovis aries*) 70, 74, 90, 308, 212, 372
 Silvery scurfpea (*Psoralea argophylla*) 165
 Sikhism 358, 336
 Sloe plum (*Prunus spinosa*) 142
 Sobotka, Primus 195
 Society for Economic Botany 6, 17
 Society of Ethnobiology 6, 17
 Soil and sediment analysis 17, 18
 Soil enhancement 286, 298, 301
 Mulching 290, 292, 296
 Soil aeration 289–90
Solanum lycopersicum (Tomato) 182
 Song 22, 294, 368
 Toponymic 278
 Sonoran Desert 165
 Sorghum (*Sorghum*) 89, 360
Sorghum (Sorghum) 89, 360
 Sovereignty 22, 35–6
 Genetic Resources 39, 53
Spermophilus parryi (Arctic ground squirrel) 142
 Springbank clover (*Trifolium wormskoldii*) 296
 Spruce (*Picea*) 142, 180, 322
 Stamets, Paul 214, 227
 Starch analysis 151, 163, 183
 Starch grains 151, 163, 183
 Stewardship 21–3, 41, 286–7, 299–301
 String theory 4
 Subsistence strategy 19, 285–6, 290, 288–300, 374
 Succession 20–1, 271, 301, 360
 Sucusari watersheds 59
 Sui generis law 37, 41
 Sun Dance 70

- Superstition 20, 315
 Sustainable development 30, 32, 40, 117, 142, 205
 Sustainable ecology 46, 241, 286–99
 Svabo, Jens Christian 194
 Sweet potato (*Ipomoea batatas*) 177–9, 324
 Swidden farming 288, 300, 310–1 *see also* Fire and Burning
 Sycamore fig (*Ficus sycomorus*) 354
 Symbolism 352–5, 310–1, 358, 361
 Kinship 294
 Plant Symbolism 351–68
 Religious/cosmological 5, 275, 353
 Synonym 29, 322
 Szulczewski, Jerzy Wojciech 203
- Tagish 142
 Taphonomy 99–101, 155, 157–8
 Taro (*Colocasia*) 178–79
 Taxonomy 5, 137, 183, 201, 326–7, 344
 Tea (*Camellia sinensis*) 259, 363
 Terracing 176, 178, 294
 Textiles 3, 205
Theobroma cacao (Chocolate) 162, 193, 324
 Three Mile Island 30
 Tilling *see* Digging and Tilling
Tilia sp. (Basswood) 142
 Tkarihwaié:ri Ethical Code of Conduct on Respect for the Cultural and Intellectual Heritage of Indigenous and Local Communities Relevant for the Conservation and Sustainable Use of Biodiversity 38
 Tlingit 91, 142
 Tobacco (*Nicotiana*) 161, 165, 224, 299, 306, 309, 323–4
 Toledo, Victor 7, 270
 Tomato (*Solanum lycopersicum*) 182
 Topography 179, 194, 277, 280
 Toponym 201, 271, 277–9
 Totems 73, 92
 Traditional agricultural knowledge 2, 10, 43, 90, 135–7, 183, 190, 315, 330
 Traditional Ecological Knowledge (TEK), 2, 3, 5, 8–9, 11, 20–1, 28, 32, 135–8, 286–301, 372
 Traditional knowledge 2–3, 10, 27–8, 30, 32–3, 35–46, 56–7, 198, 208, 278
 Public databases 45
 Traditional Resource Environmental and Knowledge (TREM) 286–301
 Methods 292–4
 Systems 293–5
 Treatises 35, 38, 148, 362
 Tree cropping 311, 315
 Transplanting 150, 240, 286, 289–1, 294, 296, 299, 306, 309
 Tri-Council Policy Statement 31, 53
 Tsembaga 89
 Tubers 42–3, 88, 108–9, 151–2, 158, 165, 176, 182–3, 290, 308, 313
 Tulip (*Tulipa* sp.) 321, 363–4
Tulipa sp. (Tulip) 321, 363–4
 Tuskegee Syphilis Study 30
 Typology 67, 321, 328
Typha L. (Cattail) 163
- Urbanization 315
 United Nations 3, 31, 35, 37, 148
 UN Treaties 38–9
 Unionidae (Mussels) 124–6
- Vaccinium vitis-idaea* (Crowberry) 198
 Vickery, Roy 201
Vicugna pacos (Alpaca) 308
 Vietnam War 31
 Vilbaste, Gustav 202
Viola odorata (Violet) 361–3, 365, 367
 Violet (*Viola odorata*) 361–3, 365, 367
Vitis (Grape) 150, 182, 309, 355, 359, 364
 Voucher specimens 82, 140, 195, 197–8, 202, 237, 244, 258, 278, 312
- Wakashan 296
 Watahomigie, L.J. 22
 Water lily (*Nymphaea caerulea*) 357
 Waterlogging 152, 175, 176
 Wing, Elizabeth 6
 Witsuwit'en 272–3, 275–7, 279
 Weeding 242–3, 286, 296, 299, 313
 Wetsite archaeology 17
 Wheat (*Triticum* L.) 5, 176, 184–5
 White Oak (*Quercus alba*) 320–2, 327
 White-Tailed Deer (*Odocoileus virginianus*) 119–21, 301
 Wilderness 71–2, 190, 222, 287
 Willow (*Salix*) 164, 272, 299
 Wola of New Guinea 271, 273
 Wolf (*Canis lupus*) 72–3, 75–6, 329
 Oral traditions 67–9, 76–7
 Wood 155–6, 158, 163–5, 180
 Fuel 155, 290
 Woodland management 290
 Woodruff (*Asperula odorata*) 198
 World Health Organization 253
 World Intellectual Property Organization (WIPO) 39

- Xingu River 32
- Yam (*Dioscorea*) 9, 177
- Yangzte River 175
- Yeast 213, 309
- Yellowstone 71–2
- Yew wood (*Taxus baccata*) 142, 191
- Yoruba 219, 235
- Yucatec 4, 8
- Yurok 67
- Zooarchaeology 2, 6, 18, 101, 112, 116,
290, 296
- Zoology 7, 16–7, 191, 205, 208
- Zoroastrianism 359, 366
- Zapotec 4, 5, 85, 90, 320



Figure 12.1 Albanian women from Kelmendi in the northern Albanian Alps smelling spiguel (*Meum athamanticum*), which is locally used as a cosmetic plant. Photograph courtesy of Andrea Pieroni.



Figure 12.5 A herbal bouquet from Stary Żmigród (the Beskid Niski Mountains). Such bouquets are still brought to Polish churches on Assumption Day (15 August). They are believed to acquire a healing and magical power. Photograph courtesy of Łukasz Łuczaj.



Figure 12.7 The regal fern, *Osmunda regalis*, is still a popular domestic medicine in Asturias and Cantabria, Spain. (a) Shows the gathered rhizomes of the fern; and (b) a bottle of *Antojil* wine made of the rhizomes macerated in white wine. Photograph courtesy of Manuel Pardo-de-Santayana.

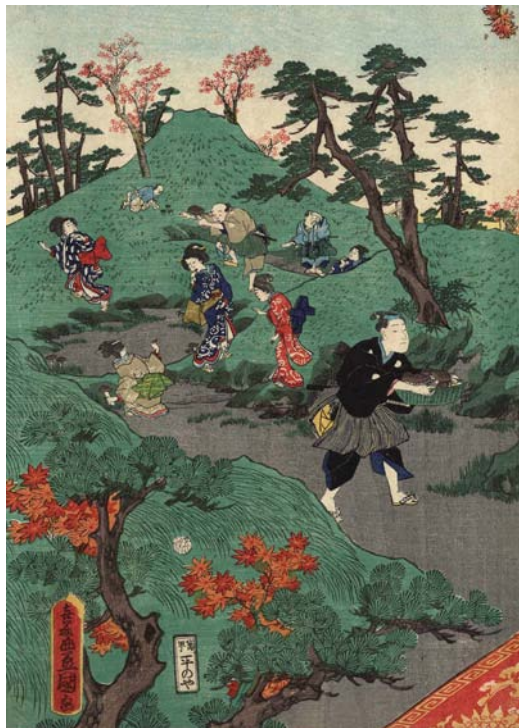


Figure 13.3 Fragment of a block print by Utagawa Kunisada (1786–1865), depicting mushroom collectors. Courtesy of the Wasson Collection, Harvard University.



Figure 13.4 Although *Amanita muscaria* is known as a psychoactive mushroom, this batch, collected during an annual Northern California Mendocino Coast Foray, was cooked for dinner following a simple detoxification procedure (see Rubel and Arora ()). Photograph by Sveta Yamin-Pasternak (2008).



Figure 13.5 While the retail price of this 6000 mg (0.21 ounce) bottle of *Grifola frondosa* extract for the author's dog, recommended by a holistic veterinarian as an immune system booster to assist the dog's struggle with bone cancer, averages around US\$80, the home-pickled batch of the same mushroom (also known as Maitake and Hen of the Woods) was freely available to pick in a forest. In the cookery of Russian and other Slavic cultures pickled mushrooms are ingested as a "chaser" with a shot of hard liquor. Photograph by Sveta Yamin-Pasternak (2009).



Figure 15.3 Pohnpeian fish traditionally prepared with fermented breadfruit balls. Photograph courtesy of kpstudios.



Figure 15.4 Salome Yesudas separating food seeds by season in the Zaheerabad Dalit area, India. Photograph courtesy of kpstudios.



Figure 17.3 Aerial photograph of the intertidal resource management feature in Northern Coast Salish territory taken at an extreme low tide. This feature combines various management elements and illustrates part of the continuum of TREM on the Northwest Coast. The beach has been cleared of cobbles to create a more productive clam habitat and walls were created with these cobbles to extend the suitable clam habitat seaward. On the right side of the photo, cobbles are used to create walls of a small fish trap. This trap would have functioned by catching fish on an incoming or outgoing tide, when water moves through the area rapidly. At the margin of the forest, the cobbles have been cleared away in a small path to create a canoe skid. In the forest is a small archaeological site composed of shellfish and fish collected from these features. A radiocarbon date from the base of this archaeological site dates to xxxx. The width of the cleared beach is approximately 20 m. Photograph by Georgia Combes, used with permission.



Figure 17.4 Australian Aboriginal women, Kiwirrkurra, burning grasslands to hunt goanna lizards, 2002. Insert: lighting fire (see smoke column in background); the main picture is dinnertime camp the same day in the burned area. Photographs by Laurie Walsh, used with permission.



Figure 17.5 Stages of the “milpa cycle”: from the newly burned plot to maize canopy with squash and beans in four months, succeeding into a diverse open fruit and hardwood orchard in 5–7 years. Between 14 and 18 years later, this orchard culminates in a forest garden of useful trees and palms, which matures 20–30 years after the initial burn. Burned field photograph courtesy of BRASS/El Pilar Project; other photographs by Macduff Everton, used with permission).



Figure 21.2 Sunday Palm procession of penitential *nazarenos* wearing medieval robes and holding branches of olive and palm leaves (Zaragoza, Spain). © Tomás Vela Esperebé.



Figure 21.3 Buddhist monks in Doi Suthep Temple (Chiang Mai, Thailand) holding lotus flowers while praying. © Santino Livoti.



Figure 21.4 May *Maia*, a tradition linked with the rituals of spring (Beja, Portugal).



Figure 21.7 The Medieval *Hortus Conclusus* (Upper Rhenisch Master, ca. 1415, Städel Museum, Frankfurt am Main). © Stadel Museum—ARTOTHEK.