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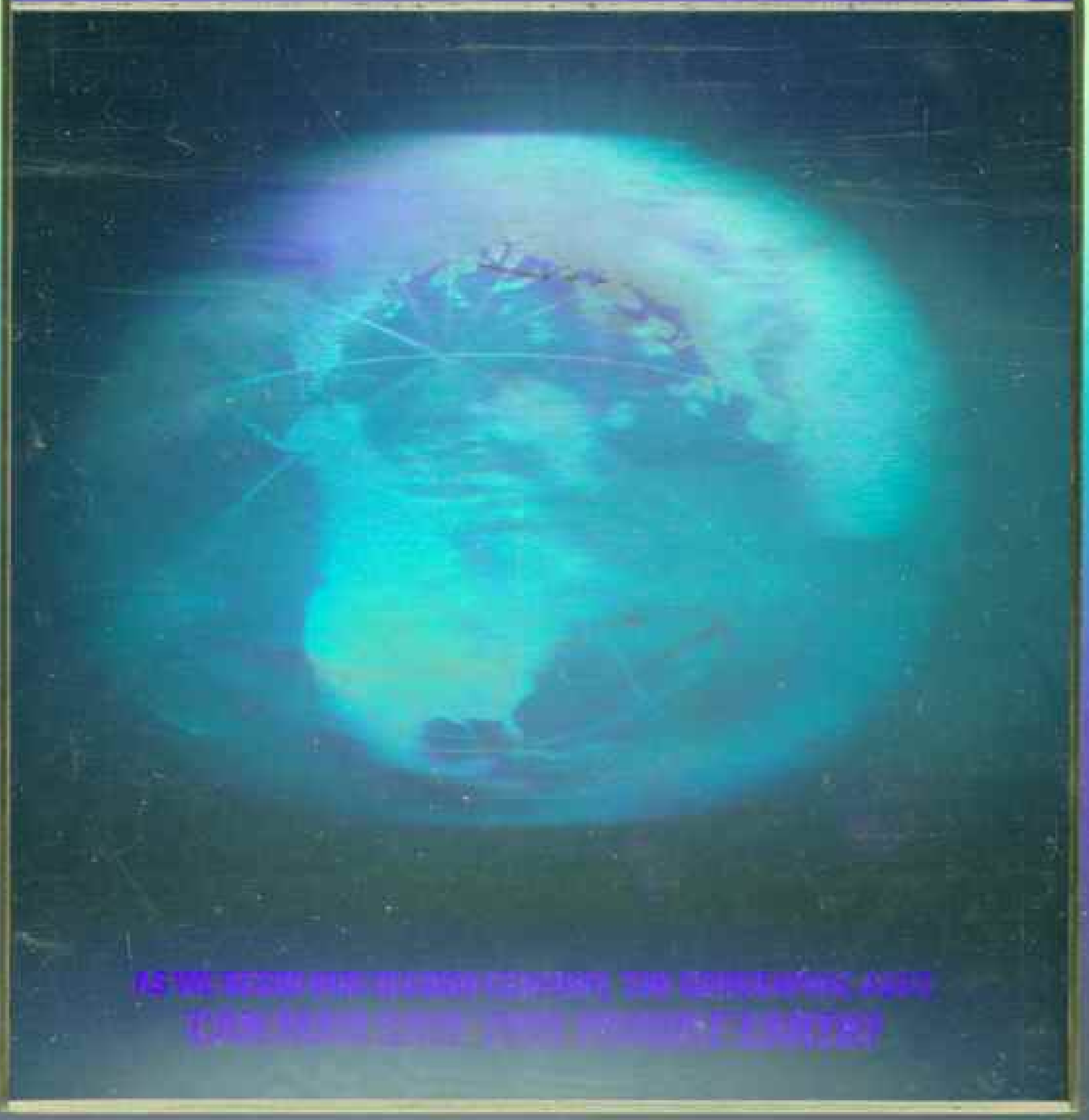


IRRR 1988

NATIONAL GEOGRAPHIC

DECEMBER 1988

SETTLER IN RONDÔNIA

ENDANGERED KIT FOX

MIGRATING CARIBOU

HUMPBACK WHALE

FARMER IN INDIA

COVER: SYMBOLIZING THE PLANET'S FRAGILITY, A CRYSTAL GLOBE APPEARS WHOLE AND THEN SHATTERS AS THE THREE-DIMENSIONAL IMAGE IS TILTED UNDER A SINGLE LIGHT BULB; DIRECT SUNLIGHT IS IDEAL. COVER IMAGE PRODUCED BY AMERICAN BANK NOTE HOLOGRAPHICS, INC.

Will We Mend Our Earth?

By GILBERT M. GROSVENOR PRESIDENT AND CHAIRMAN OF THE BOARD

THE NATIONAL GEOGRAPHIC SOCIETY began its first century with a determination to better understand the world. We have begun our second with the same determination but with an added imperative: to encourage a better stewardship of the planet.

During one brief century mankind has passed the point of global opportunism and entered an era of global protection. There is hardly a place in this land where the lesson is not written plain for all to see.

I have sailed the Chesapeake Bay, for example, for half a century. With its rich melding of forest, field, water, and sky, the Chesapeake has always represented to me the best of this nation's outdoor heritage. Considering the wealth in its waters (the blue crab catch alone exceeds 30 million dollars a year), the productivity of its tilled fields, and the collection of industry along its shores, it has seemed a microcosm of the developing world.

Increasingly, though, the shoreline and creeks are sprouting clusters of condominiums, and the wetlands that draw hundreds of thousands of ducks and Canada geese each fall are being drained, bulldozed, and built over.

The verdant fields are still productive, thanks in part to herbicides and fertilizers that are chemically altering marine life. A recent study points to acid rain as a major contributor of the nitrates that are overnourishing the bay, promoting algal growth that uses up oxygen and crowds out sunlight. The primary source: motor-vehicle exhausts in the eastern United States. Industrial pollutants all along the watershed have joined the farms and cities in a knockout blow, leaving the water so opaque that I don't encourage my young son to swim in it, as I myself once did. The bay is a microcosm all right, of what we have become, what we must correct, and what we have to avoid in the future.

Here at the Geographic we have been cruising the waters of our own history throughout this year, celebrating a century of what we call our "voyage of discovery." Last January we reprinted the inaugural address of the Society's first president. Gardiner Greene Hubbard spoke eloquently of diffusing geographic knowledge, "so that we may all know more of the world upon which we live." His conclusion, "The more we know, the greater we find is our ignorance," rings louder today than it did then. Much has been learned and accomplished over the past century, but the soiling of the Chesapeake Bay only proves the elusiveness of true wisdom.

We live in a changed world from that of 1888, and we are a changed nation. Our founders knew an America with rising expectations, while we see a superpower riddled with self-doubt. Tropical forests were a mysterious challenge in 1888. The challenge in 1988 is saving them from disappearance. Automobiles had just been invented, and airplanes were unknown. Would our founders be impressed by rush-hour traffic, a brown cloud over Denver, or aerial gridlock at Chicago's O'Hare Airport? Could they have conceived of a Mexico City with 20 million people in an atmosphere so murky that the sun is obscured, so poisonous that school is sometimes delayed until late morning, when the air clears?

LAST JANUARY the Society held a symposium on global prospects, sponsored by our Committee for Research and Exploration. Distinguished scholars from many disciplines (following page) assessed developments in their respective fields and urged corrective measures for the future. For five days and nights our auditorium rang with vision, criticism, celebration, and admonition, a mind-filling compendium of the state of the world.*

There was much to celebrate. Frank Press, president of the National Academy of Sciences, pointed out that we are in the golden age of science, with one technological revolution following another. Our founders lived in the midst of two: steam power, and the use of fossil fuels and electricity. The third and fourth came with the arrival of nuclear fission and the transistor in the 1940s. The atom became both servant and global threat, while the transistor changed the way we communicate and organize our services.

We are now at the dawn of a fifth, the biological revolution. The deeper understanding of the molecular makeup of cells makes it possible to manipulate the genes of plants and organisms, which should have enormous impact on agriculture and human health. Genetically engineered plants could be steered toward increased productivity, nutrition, and resistance to disease, reducing the need for pesticides and fertilizers. Biotechnology is also creating wholly new ways of detecting and treating terrible human diseases.

Other exciting developments glimmer on the horizon: electrical superconductivity, improved ceramics, and new thin films and interfaces between materials. Everyday tools unimaginable to us now will spring from these, for, as Press noted, in modern science the pace of discovery accelerates at an ever increasing rate.

Unfortunately there are drawbacks to our genius. For too long we were blinded by the positive side of technology and ignored the slowly emerging dark side, as was pointed out by Jerome B. Wiesner, president emeritus of the Massachusetts Institute of Technology. We ignored it because in the infancy of modern technology the dark side was not yet discernible.

During the inauguration of this Society electric lamps were seen as a blessing of progress. Who then could have imagined tension between the United States and its old friend Canada over emissions caused by the coal-fired generation of electric power? In 1895 the advent of the automobile was hailed as a remedy for city pollution . . . by horse manure. Now we decry the car's contributions to acid rain, man-made ozone, blood-lead content, and carbon dioxide buildup. Air-conditioning, what luxury! Spray cans, what convenience! Then we learned that the chlorofluorocarbons used in both help destroy the stratospheric ozone that protects us from cancer-causing ultraviolet radiation.

When there were only a few hundred thousand automobiles and fewer refrigerators than true iceboxes, and when spray propellants were just a World War II tool in the battle against malaria, opposing them was unthinkable. Their destructive impact has come with the surge in their popularity, in the world's bulging population, and consequently in their increased use. Disposal of the bitter fruits of high consumption—trash and toxic waste—has become an intractable problem. We are victims of our own success, drowning in our own garbage.

"People everywhere are offended by pollution. They sense intuitively that we have pressed beyond limits we should not have exceeded. They want to clean up the world, make it a better place, be good trustees of the earth for future generations."

—JAMES GUSTAVE SPETH,
President, World Resources Institute

*To order a copy of "Earth '88: Changing Geographic Perspectives" ($20 postpaid), please write National Geographic Society, P.O. Box 1640, Washington, D.C. 20013.

Participants in the symposium on global prospects:

New Incentives: From Patrons to Publics
DANIEL J. BOORSTIN *Librarian of Congress Emeritus*

Motors of the Mind: New Prospects and Visions for Mankind
LEWIS M. BRANSCOMB *Professor, John F. Kennedy School of Government, Harvard University*

What the Climatic Past Tells Us About the Environmental Future
REID A. BRYSON *Professor of Meteorology, Geography, and Environmental Studies Emeritus, University of Wisconsin–Madison*

Populations of People and Other Living Things
PAUL R. EHRLICH *Bing Professor of Population Studies, Stanford University*

Political Geography and International Relations
GEORGE W. HOFFMAN *Professor of Geography Emeritus, University of Texas at Austin*

Geography and Public Health
JOHN M. HUNTER *Professor of Geography and of Community Health Science, Michigan State University*

Ecology and Management of Desertification
MOHAMED A. F. KASSAS *Professor of Applied Botany Emeritus, University of Cairo*

The Spirit and Impact of Exploration
GEORGE KISH *Professor of Geography Emeritus, University of Michigan*

Space Flight: One of Man's Most Challenging Adventures
CHRISTOPHER C. KRAFT, JR. *Former Director, Johnson Space Center, NASA*

Quality of Life
DONELLA H. MEADOWS *Professor of Environmental Studies, Dartmouth College*

The Oceans
WILLIAM A. NIERENBERG *Director Emeritus, Scripps Institution of Oceanography*

An Earth Ethic: Our Choices
RUSSELL W. PETERSON *Symposium Chairman; President Emeritus, National Audubon Society*

Science and Technology: The Keys to Our Future
FRANK PRESS *President, National Academy of Sciences*

The Cause and Impact of Deforestation
PETER H. RAVEN *Director, Missouri Botanical Garden*

Impact of the Communications Revolution
JAMES B. RESTON *Senior Columnist, the New York Times*

Environmental Pollution
JAMES GUSTAVE SPETH *President, World Resources Institute*

Global Agriculture at the Crossroads
M. S. SWAMINATHAN *President, International Union for Conservation of Nature and Natural Resources*

Geography and Human Mobility: The Perpetual Revolution in Transportation
JAMES E. VANCE, JR. *Professor of Geography, University of California, Berkeley*

A Century of Change in World Water Management
GILBERT F. WHITE *Gustavson Professor Emeritus, Institute of Behavioral Science, University of Colorado at Boulder*

How Societies Learn
JEROME B. WIESNER *President Emeritus, Massachusetts Institute of Technology*

The Impacts of Energy Development and Use
THOMAS J. WILBANKS *Corporate Fellow and Senior Planner, Energy Division, Oak Ridge National Laboratory*

The Diversity of Life
EDWARD O. WILSON *F. B. Baird, Jr., Professor of Science, Harvard University*

FALSE-COLOR COMPOSITE VIEW OF EARTH WITH DATA FROM SYNCHRONOUS METEOROLOGICAL SATELLITE 2 AND GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE-EAST. GEOPIC™ BY KAMANA J. ESTEP, EARTH SATELLITE CORPORATION, CHEVY CHASE, MD., COURTESY GARY WADE, NOAA, AND WILLIAM A. LAGERDOCE, SPACE SCIENCE AND ENGINEERING CENTER, UNIVERSITY OF WISCONSIN-MADISON.

PERHAPS NOTHING so illustrates the change from the world of our founders to our own as the leap in human population. One and a half billion people occupied this planet when the National Geographic Society was formed. Now there are more than five billion. Although the growth rate has declined, demographers expect the planet's population to double in this coming century—to ten billion. We are already overpopulated, biologist Paul R. Ehrlich of Stanford University, another symposium speaker,

"In the 1990s and in the 21st century, the greatest food security challenge will be economic and/or ecological access to food, arising from inadequate purchasing power on the one hand and environmental degradation on the other. Global agriculture is at the crossroads. We need . . . to meet the new challenge."

—M. S. SWAMINATHAN,
President, International Union for Conservation of Nature and Natural Resources

explains—in terms a banker would appreciate—in an article co-authored with his wife, Anne H. Ehrlich, in this issue (page 914).

Other presentations at the symposium echoed similar concerns. At current rates of destruction much of our tropical forests, the most biologically diverse areas on earth and source of numerous medicines, will be gone within 25 years, predicted Peter H. Raven, director of the Missouri Botanical Garden. Erased with them will be at least a million species, probably many more, of which only a relative handful have been tested for possible use by man. According to Mohamed A. F. Kassas of the University of Cairo, some 20 million square miles and nearly a billion people are affected by desertification. Russell W. Peterson, president emeritus of the National Audubon Society, cited studies showing world oil production peaking in a decade or two before falling into irreversible decline.

Remarkable increases in food production have been achieved over the past one hundred years, reported M. S. Swaminathan, president of the International Union for Conservation of Nature and Natural Resources. Yet the number of hungry people has increased because of rapid population growth, poor distribution, and political problems. The best agricultural lands are already being farmed, and necessary increases in productivity must come from marginal land—made marginal by nature or by man's abuses through deforestation, overgrazing, and air and water pollution. Tropical forests may be rich biologically, but laid bare they often expose fragile, unproductive soils.

Water may cover most of the earth's surface, but nearly two billion people in the developing world lack safe drinking water. Most of the population increase will take place there.

Further complicating the global picture is the greenhouse effect of increased carbon dioxide, methane, and other gases caused by man's activities. The buildup of these gases, scientists have long said, has committed us to a warming of earth's temperatures within the next half century. One disastrous consequence, according to William A. Nierenberg of the Scripps Institution of Oceanography, would be the melting of polar ice and a resulting rise in sea levels. Disruption of rainfall and soil moisture patterns could change the fortunes of nations, reported James Gustave Speth of the World Resources Institute.

Already those fortunes are woefully out of balance. A quarter of the earth's people, located in industrialized countries, control 80 percent of its resources. Some of us live better than royalty a century ago, while another quarter of the world's population today languishes in poverty. And unbelievably, in this golden age of science 40,000 young children die of hunger and related diseases each day.

While concern was a recurrent theme in the presentations, despair was absent.

Virtually every speaker held that current problems and potential problems could be met, and examples of success were cited frequently. China, once considered the vanguard of the population explosion, has curbed its growth to near-replacement level while raising the standard of living and extending life expectancy.

Large-scale efforts around the world have shown that soil erosion and desertification can be arrested when the proper effort is made. Tropical forests do not have to be leveled to feed people; Peter Raven pointed out that innovative methods of cultivation in forested areas can sustain relatively high population densities. Grazing and fishing can be practiced in sustainable ways. Swaminathan outlined a seven-point action plan he said can guarantee "nutrition security" for any country.

The resources exist, said MIT's Wiesner, to start rebuilding a world that is in ecological and human equilibrium. Surveys in this country have shown that citizens increasingly support environmental protection measures, a message many politicians seem to be missing. Recently I witnessed that support, and a willingness by individuals to become involved, when I traveled around the country with the President's Commission on Americans Outdoors. True equilibrium, true improvement in the quality of all our lives, will happen only when an informed and dedicated population wants it to happen. That's where the National Geographic Society comes in.

WE SUPPORT the voices of reason that call for restoration of environmental balance to planet earth. Public awareness, education, protecting our national heritage, and recognizing our global responsibility are recurrent themes in our journal.

Yet I worry that we did not do enough soon enough to warn our members about what was happening. Acid rain, deforestation, shrinking wetlands, air pollution—these will be major issues for decades. And like millions of others I am haunted by the potential for nuclear destruction in the hands of nations that show a worrisome inability to resolve their differences.

All our concerns, all our hopes point to a need for better knowledge of geography. How can we hope for good stewardship of this planet if we don't know how life interacts with life? How can we hope to live peacefully with our fellow man if we don't comprehend where or how he lives? How can we hope to remain a successful economic competitor if we know so little of the nations we are competing against?

This magazine and this Society have focused on these issues in the past, and we must do even better in the future. With all

"The challenge is . . . to mobilize, to start rebuilding a world that is in ecological and human equilibrium."

—JEROME B. WIESNER, President Emeritus, Massachusetts Institute of Technology

the tools at our disposal—computer-aided research, faster picture transmission, laser videodiscs, satellite TV hookups—we plan to alert the public to the dangers outlined in our symposium. Our National Geographic Education Foundation, announced earlier this year, is aimed not only at obliterating geographic illiteracy among the young but also at creating future geographers who are sensitive to the needs of this planet. Our expenditures for research grants have risen steadily over the past decade, and increasingly they are awarded for studies of the problems posed by our symposium.

If mankind's greatest advances occurred in the first century of this Society, perhaps the greatest challenges lie in the second. The stakes could not be higher. As Harvard scientist Edward O. Wilson told us, "How the human species will treat life on earth, so as to shape this greatest of legacies, good or bad, for all time to come, will be settled during the next hundred years."

The responsibility lies squarely with us. Will future generations praise our foresight or look back in anger and dismay at what we had, and what we lost forever? □

"It appears likely that no fewer than 1.2 million species, at least a quarter of the biological diversity existing in the mid-1980s, will vanish during this quarter-century or soon thereafter, and that a much higher proportion of the total will follow by the second half of the next century, as the remaining forest refuges are decimated."

—PETER H. RAVEN, Director,
Missouri Botanical Garden

Amid debris of cut and burned trees, a couple construct a new house near Mirante da Serra.

Rondônia's Settlers Invade Brazil's Imperiled

By WILLIAM S. ELLIS ASSISTANT EDITOR

WILLIAM ALBERT ALLARD

Rain Forest

Photographs by WILLIAM ALBERT ALLARD and LOREN McINTYRE

"How can you do this to us?" rages a settler. "The Indians have lots of land. We have so little. They're lazy, and we're working hard to make something of this place." Six years ago INCRA, then the government's land-settlement agency, set up these colonists at the end of a road northeast of Ji-Paraná. No one realized until too late that the land lay inside the Igarapé Lourdes Indian reserve. When representatives from the

National Foundation for the Indian (FUNAI) arrived to evict them in 1986, settlers blocked the road. The confrontation turned into a shouting match in the local schoolhouse; police stand by the windows at right. After the colonists were moved out, the Indians burned their settlement. Conflicts like this often arise where land development occurs alongside protected areas.

BUILT BY LOREN MCINTYRE

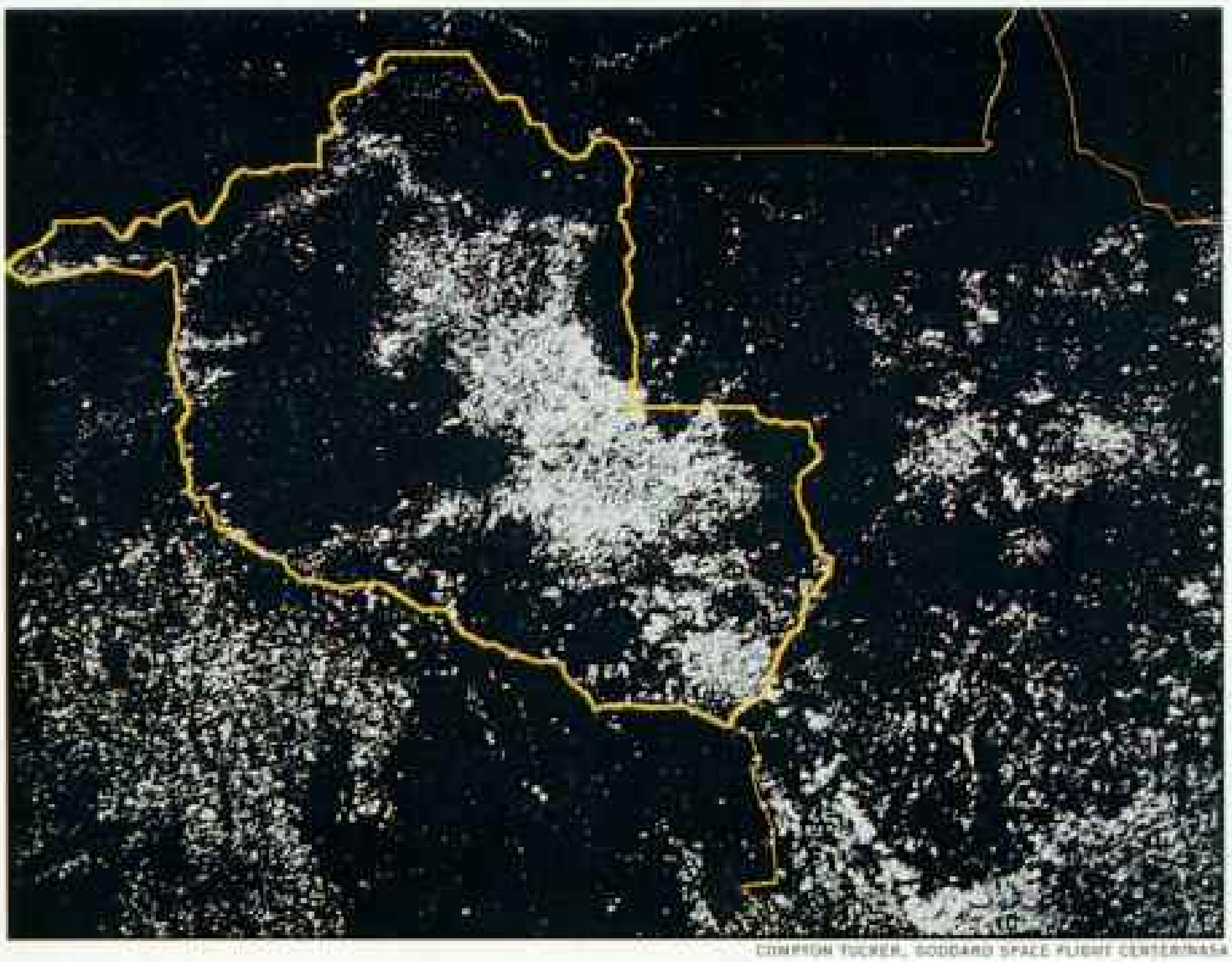
Slicing streets into the wilderness, INCRA in 1970 founded Ouro Prêto do Oeste (right), where it headquartered settlement operations. Fertile lands flank this stretch of BR-364, and farmers have received substantial technical assistance. Poor soils and a rough ride have not kept colonists from following BR-429 (above), which passes ecological preserves on its way from BR-364 to the Bolivian border.

MARCOS SANTILLI

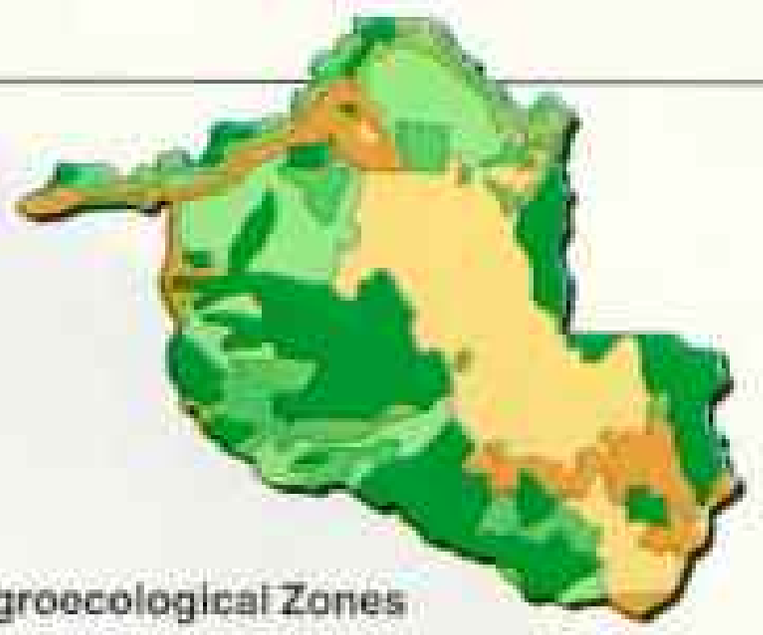
Will the rain forest survive?

COMPETING CLAIMS for land divide Rondônia into a patchwork of parcels. Settlers clear plots along the network of feeder roads off Highway BR-364 by burning off cut timber at the end of the dry season (above). These fires appear as light spots in a composite satellite image spanning several weeks in 1987 (below).

As part of its 432 million dollars in loans for the Polonoroeste development project, the World Bank in 1981 required Brazil to set up preserves sheltering the rain forest and the Indians living in it. Under pressure of a land rush that added more than half a million to the state's population during this decade, the agreement has been frequently breached, and deforestation has continued even in protected areas.



COMPTON TUCKER, GODDARD SPACE FLIGHT CENTER/NASA



Agroecological Zones

Based on satellite images and soil samples, agroecological zones have been designed to defend the rain forest from developers. Brazil hopes to receive some 200 million dollars more in World Bank loans to implement the system.

- INTENSIVE AGRICULTURE
- MIXED AGRICULTURE/DAIRY
- RIVERINE AGRICULTURE
- GATHERING OF FOREST PRODUCTS
- SUSTAINABLE TIMBER EXTRACTION
- CONSERVATION UNITS (PROTECTED)

AMAZONAS
TRANS-AMAZON HIGHWAY
Madeira
Ji-parana (Machado)
CUNIÃ
TENHARIN
Samuel Dam (completed 1988)
Porto Velho
Madeira-Mamoré Railroad (abandoned)
JAMARI
KARITIANA
Jamari
Candeias
KARIPUNA
Jaciparana
Ariquemes
Bom Futuro
BR-364
Unpaved roads and agriculture
Jaru
JARU
MATO GROSSO
Farmers, loggers, and miners often invade protected areas. Too few officials patrol too much land to keep everyone out.
IGARAPÉ LOURDES
ZORÓ
Jaru
Ouro Prêto do Oeste
Ji-Parana
SETE DE SETEMBRO
RONDÔNIA
PACAÁS NOVOS
Pacaás Novos
Mirante da Serra
Presidente Medici
Alta Lidia
Alvorada do Oeste
Cacoal
ROOSEVELT
ARIPUANA
URUEU-WAU-WAU
Pimenta Bueno
Rolim de Moura
Cautário
Branco
Pimenta Bueno
Theodore Roosevelt
Tenente Marques
BR-429
RIO BRANCO
Unpaved roads and agriculture
Principe da Beira
Costa Marques
GUAPORE
RIO MEQUENS
TUBARÃO/ LATUNDE
Vilhena
Pedras Negras
Corumbiara
Swamp
IGARAPÉ OMERÉ
Colorado do Oeste
Branco (Cabixi)
NAMBIKWARA (Arisira Indians)
BR-364
Guaporé
BRAZIL
BOLIVIA

- RAIN FOREST
- MINE
- BIOLOGICAL RESERVE
- NATIONAL PARK
- NATIONAL FOREST
- INDIAN RESERVE

0 75 km
0 75 mi

Farmers typically clear-cut the forest, harvest a few seasons' crops, and leave the fields to cattle ranchers. Herds then graze for a decade or so. Exhausted, the land is abandoned. The rain forest may never be able to reclaim it.

NGS CARTOGRAPHIC DIVISION
DESIGN: DAVID B. CHANDLER
RESEARCH: KAREN ALLEN, BARBARA F. FALCONER
PRODUCTION: BARBARA CARRIGAN
MAP EDITOR: JOHN F. BLOZIS

Settlers flood the frontier

"The Bold Ones March Westward," *proclaimed a government slogan promoting the Amazon wilderness to land-hungry laborers in the 1970s. Settlers had begun the move to remote Rondônia a decade earlier, once Highway BR-364 stretched across the territory, made a state in 1981. A ribbon of red dirt, BR-364 funneled migration from the dry, overpopulated northeast and from farms in the south where machines had replaced manpower.*

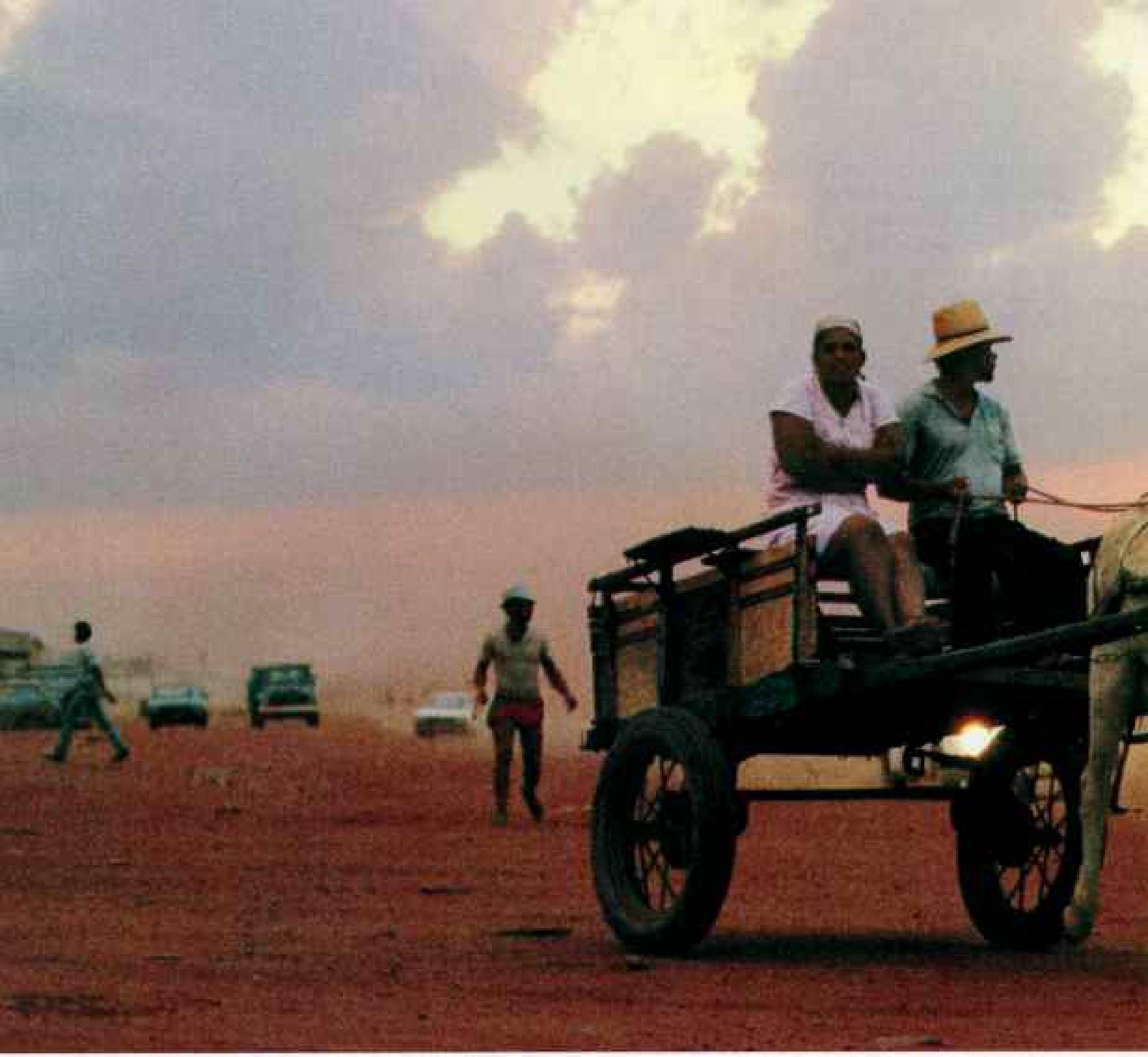
In 1984 the Brazilian government finished paving BR-364, the centerpiece of its 1.5-billion-dollar Polonoroeste regional development project. By then immigrants flooding into the state were cutting still more roads into the rain forest and clearing large tracts to secure land-tenure claims.

Rondônia's population has doubled during the 1980s. The soil in many areas cannot sustain agriculture, and instead of providing food for export, as planned, the state imports most staples. Experts estimate that more than 20 percent of the rain forest has been destroyed already.

Almost entirely undisturbed in 1973, Rondônia's rain forest appears rusty red in images made by the Landsat 1 satellite 15 years ago. BR-364 appears as a lone white track.

INSTITUTO DE PESQUISAS ESPACIAIS (INPE), SÃO JOSÉ DOS CAMPOS

Deforestation registers light blue in Landsat 5 images of the area in 1987. Main routes with auxiliary roads every few miles branch off Highway BR-364.

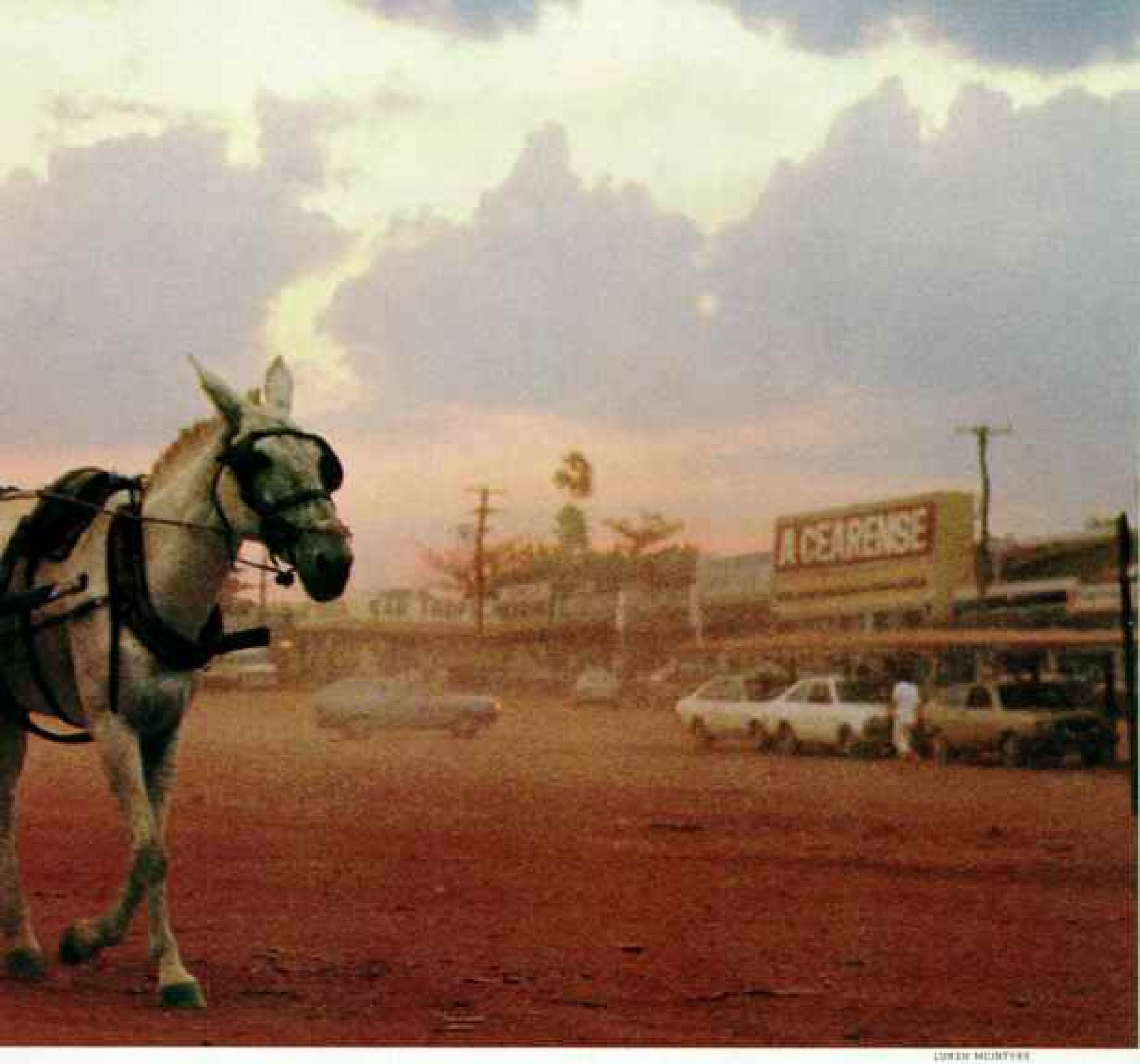


THE RUSH has slowed somewhat now, but large numbers of men and women from the ranks of the dirt poor continue to arrive, chasing dreams of a better life —riches, even—through the rain forest of Brazil, through the vast dank chambers of Amazonia, which stands today as probably the last great seductive frontier on earth.

Mostly they make their way to the rough-hewn state of Rondônia, in western Brazil, along the border with Bolivia. Given large tracts of land there by the federal government, they first fell and burn the trees (not the mahogany and cherry, though; those are sold), and then they hack and clear until the malarial acres lie blackened and scarred like a battlefield in war.

In Rondônia's capital city of Pôrto Velho, steamy and swollen now with a population of 450,000, there are people who tell of a time not far back when the jungle tightly girded what was then a lightly populated outpost on the frontier. The place lay fast by the Madeira River, a wide and brown tributary of the Amazon with the promise of gold in its sands. Few made their way to Pôrto Velho then, because access by road was virtually nonexistent.

But then a road was scraped through the length of the state, eventually linking Pôrto Velho with Cuiabá, the capital of Mato Grosso state. An ambitious highway through the Amazon, it is called BR-364. At first the 900-mile road was dirt, so when the tropical rains came each year, starting in September, it all went to thick red mud.



LUKEN MCINTYRE

In a haze of dust at sunset a mule-drawn cart joins traffic on the 300-foot-wide main street of Rolim de Moura, a rowdy town named for an 18th-century Portuguese governor. Trucks laden with logs and lumber roar along this route as they service surrounding mills. Wood products make up more than 60 percent of Rondônia's industrial yield.

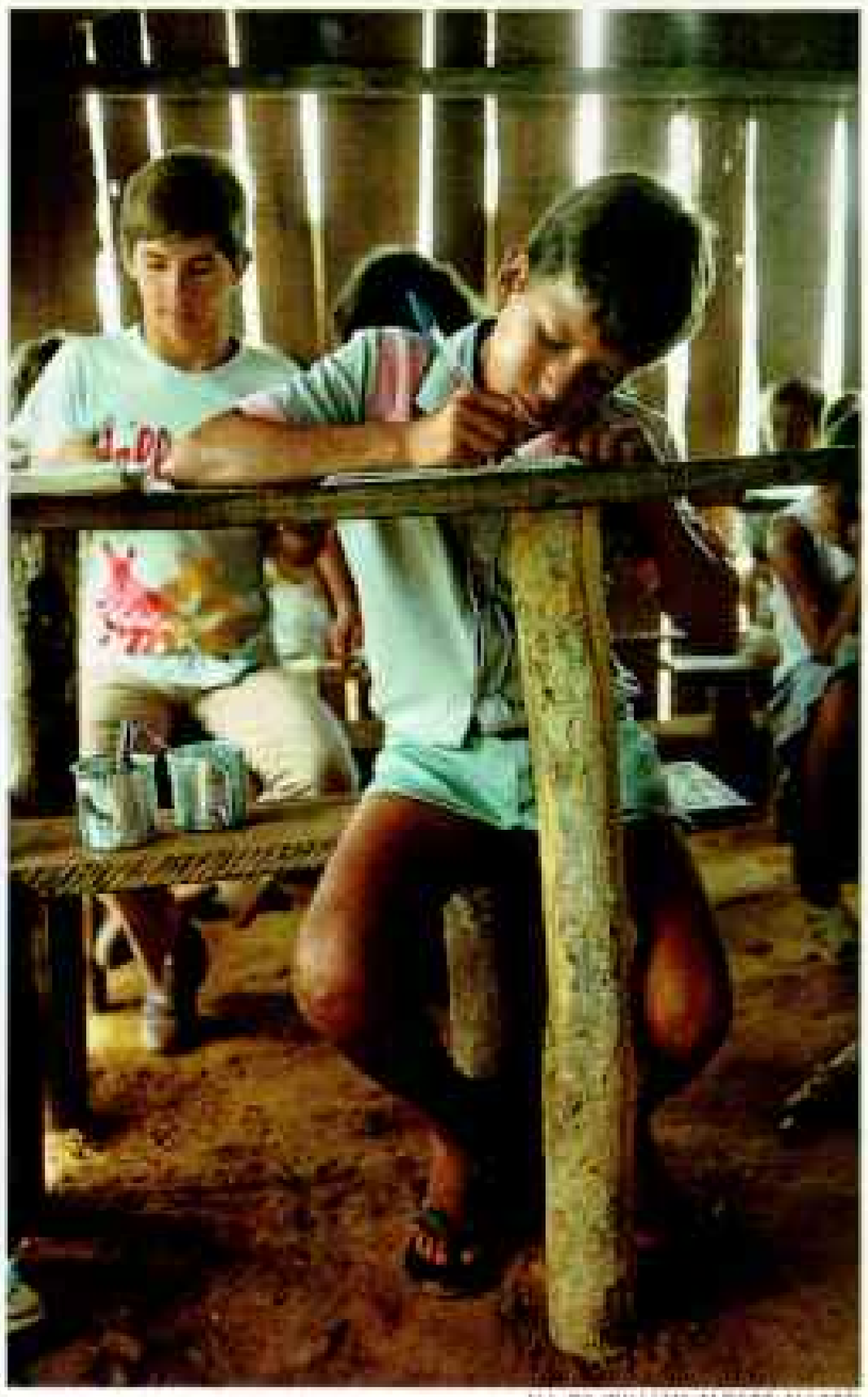
Still, the mass movement of people to Rondônia began in those years of the early 1970s; by 1984, when the paving of BR-364 was completed, the migration was turned to full throttle. There has been nothing like it since the rush to the American West by settlers.

The damage to the environment has been severe. As much as 20 percent of the rain forest may have been destroyed. Socially Rondônia has mirrored the excesses of other frontier openings: the undercurrent of lawlessness, the greedy exuberance of entrepreneurs, the guzzling, giggling night music of debauchery, and a haphazard life-style gripped by uncertainty.

And, of course, there are Indian players in this frontier drama. They are being pushed into corners, sometimes murdered.

JERÔNIMO GARCIA DE SANTANA, the governor of Rondônia, sat with his head in a shroud of cigar smoke and lamented the strain on government services. "If only immigration would fall off, we could plan and inaugurate new programs," he said. "There are 200,000 children in Rondônia who cannot go to school because there are no schools for them. And

Shouldering bananas in a basket, Lourival Evangetista heads home with his sons after tending the beans, coffee, corn, and manioc that he grows on his land near Alvorada do Oeste. Though wall boards gape and packed dirt serves as a floor, his wife, Sueli Maria, makes the kitchen sparkle. In a one-room schoolhouse nearby, neighborhood children learn elementary skills.



ALL BY WILLIAM ALBERT ALLARD

health: Malaria is getting worse. Last year there were 240,000 cases in Rondônia. That's 20 percent of the state's population."

The town of Ariquemes, south of Pôrto Velho along BR-364, is known as the "malaria capital of the world," although there is no banner across the main street proclaiming the distinction.

Fear of malaria can quickly induce a hopeful homesteader to forfeit his land claim and flee Rondônia. The critical shortage of electric power, an inflation rate in the country of close to 600 percent—such are hardships to overcome, but the dread of the chilled and feverish journey through the run of the illness is often too jarring to endure.

For many ecologists and others concerned about the state of the earth, Rondônia in 1988 has come to be regarded as an environmental holocaust. And the finger of blame is often pointed at the World Bank, the agency responsible in large measure for the paving of BR-364 and, therefore, opening up a way into the vast biome where the morpho butterfly performs in flashes of a blue more perfect and pure than that of a queen's sapphire.

"Once you build highways into those areas, then there's a process that is outside the control of the government," said Dr. Philip Fearnside, an ecologist with the National Institute for Research in the Amazon, in the city of Manaus. "That leads to clearing of the

area. Building roads in Brazil is something that's decided by a handful of people in Brasília. But you can't control what thousands of small farmers and squatters are going to do after they follow the road into the forest."

More barbed was the criticism in a letter to the president of the World Bank from Bruce Rich, then attorney for the Natural Resources Defense Council, and others. "There are strong indications," the 1984 letter read, "that the Bank has lost control over—or will not take effective measures to control—the destruction being unleashed in the region."

Stung by its critics, the bank put a hold on its 432 million dollars in committed loans until certain assurances related to environmental protection and the well-being of Indians were received from the government of Brazil. But by that time newcomers were moving into the state at a rate of 150,000 a year. The population was growing at a staggering rate of 15 percent a year. With the road paved, travel time was slashed from days—up to 30 days to travel the length of Rondônia in the rainy season—to less than two full turns of the clock.

The improvements to BR-364 were but one part of an ambitious development program called Polonoroeste, meant to cover all of Rondônia and a large segment of Mato Grosso state. Taken together, the area is known as the Northwest Region, and its boundaries enclose some 160,000 square miles of land. Up until 1970 the Northwest Region sat undisturbed for the most part, wrapped in its thick, wet heat, a place a world apart from the tanning beaches of Rio de Janeiro and the urban busyness of São Paulo.

Both drought and freeze came to Brazil in those years, destroying the coffee crops. And with other setbacks the government saw the opening of the rain forest frontier as a means of bolstering the economy through a resurgence in agriculture, with a heavy emphasis on cash crops. There, in the Northwest Region, the government would build roads and create conditions highly favorable for small farmers. The program would be of use too in reasserting Brazilian sovereignty over the border-hugging region. And, not least of all, Polonoroeste would help dispel the concentrations of the wretchedly poor huddled in slums on the fringes of the major cities.

Aiming for the corner pocket, a pool player passes the time in a Jaru bar. This boomtown with a Wild West air and a population of some 65,000 attracts gold and tin prospectors from nearby mines.

The Brazilian government, controlled then by the military, gave scant thought to protection of the environment. Rather, there was open defiance to those who were critical of the growing threat to survival of the rain forest. In 1972, for example, at the Stockholm UN Conference on the Human Environment, Brazil let it be known that if the country wished to abuse its land and pollute its waters, it had the right to do so and, if necessary, would do so, and the rest of the world be damned.

Less than a decade later, under its first civilian government in 21 years, Brazil had begun to display a newfound sensitivity to the environment (nothing of Greenpeace proportions, mind you), a development not entirely unaffected by proddings from the World Bank. Whereas the governor of Rondônia in 1981 stood on the balcony of his palace and summoned the poor of Brazil, and indeed all

the world, to come to Rondônia, the present governor says that the land can take no more for now, that the flow of people must stop, that *the invitation is rescinded.*

FOR JOSÉ CLÁUDIO DA CRUZ, it is too late for that.

"I came here from São Paulo four months ago in search of good land, and now I have what you see here," da Cruz said. "It is a hundred hectares [247 acres]. Way back there, at the end of the clearing. It is my land back to there."

His place sits along one of the many auxiliary roads that now sprout from BR-364. Few of them are paved, and they stand out like flaring red tribal marks on the face of the land. They are there because José Cláudio da Cruz and tens of thousands of others are there, pushing deeper into the jungle each day, stretching the lifeline with BR-364 until the offshoot roads themselves carry the burden of the settlers' dependency.

No matter how ardent the pioneering spirit, no one can be expected to labor in the noontime heat of the Amazon rain forest. So I went with da Cruz into the kitchen of the small shelter that stood on his place, and there we drank moonshine and chewed on strips of beef jerky.

"My wife is dead," he said, digging his bare feet into the cool depths of the room's dirt floor. "I left my three children in São Paulo, and now I must send for them. I don't think they will want to come, and when they get here, I don't think they will want to stay. But for me, I am glad I came. There are problems, of course—the malaria is the worst—but I intend to stay."

It is always with the intention of staying that they settle on the land, but for many the dream is over in three or four years. By then the ash from the tree burnings, having acted as a magic potion on the newly bared soil, has dissipated—spent the last of its good nutrients on the floor of the clearing—and so the subsistence crops of corn, dry-land rice, and beans start to fail. With no money to buy fertilizers, the settlers move. Rather than return home, many make a second try at homesteading, often in the neighboring state of Acre. Paving of BR-364, from Pôrto Velho to Acre's capital city of Rio Branco, is continuing, financed now by the Inter-American Development Bank.

There is heavy irony in that the soils of the Brazilian rain forest are so lacking in nutrients and yet support such a diverse and rich ecosystem—probably more than a million species of plant, animal, and insect life. But that is the genius of the jungle's workings, the synchronized meshings of taking from here to give to there. It all breaks down, however, when there is a major disturbance from the outside. In the area covered by Polonoroeste, only 17 percent of the soil is good for farming. Almost all of that is found in central and southern Rondônia, within a strip extending for 65 miles on either side of BR-364.

"The money I get now and the food I grow give me the right to survive and nothing more," da Cruz said. "But I am hoping for better things."

It began to rain, and soon the soil of the clearing was being beaten into mud.

BOTH BY WILLIAM ALBERT ALLARD

With one last look, an entertainer in an Ariquemes brothel checks her costume before going on stage. When her striptease ends, she will change to work clothes and join customers for drinks.

Shoveling soil into sluices, garimpeiros, or prospectors, extract ore from what may be Brazil's richest alluvial tin deposit. Discovered last year, the lode has drawn tens of thousands of miners to the rugged Bom Futuro camp west of Ariquemes. Thieves make strikes of a different sort here—their gunfire starts at sunset and continues all night. Police are trying to bring order to the area, where commercial mines also operate.

Da Cruz, a tall, dark man, pushed away from the table and walked to the door, where he looked out on a clump of flowers with petals flared like a trumpet. Bumblebees as big as hummingbirds were busy there, prompting da Cruz to observe that insects are about the only wildlife still around in the cleared area. Even the snakes are gone.

HIS PLACE is not far from Rolim de Moura, a town some 40 miles west of BR-364 by way of a side road only partly paved. Founded just 13 years ago, Rolim de Moura now has a population of 110,000. It wasn't meant to be that way. The town was originally planned as a modest agriculture center in the Polonoroeste development scheme.

They came on foot and by bicycle. They came clinging to one another as they rode on top of cargo in trucks that undertook the axle-breaking journey along the access road. They came in the rain, and they came during the dry season when the smoke from burning trees was so thick and far-reaching that several commercial airports in northern Brazil had to close because of poor visibility. Thousands of plots of land, some of 125 acres and others twice that size, were handed out in the Rolim de Moura region by Brazil's National Institute of Colonization and Agrarian Reform (INCRA).

And when they came to claim the land, they brought with them all the social ills of a frontier boom. In one month of 1984 the town recorded more than 30 deaths by gunshot.

"Yes, at the beginning there was a lot of crime," Valdir Raupp de Matos, the mayor of Rolim de Moura, said. "But the police have put a stop to that now. What remains critical is the lack of services for the number of people here. The federal government has lost control of that situation. There is no place left here for new people. If you want land, you have to buy it."

With that much land being distributed and cleared, there was an abundance of salable timber coming out of the area, and for a time it was Brazil's leading producer of lumber for export. "While the timber business has fallen off, agriculture is building up," Mayor de Matos said. "In the end it will be agriculture that keeps this city alive."

The dust and mud of the road's red clay lie thickly on Rolim de Moura, and even on some of the men who sit outside a hotel on the 300-foot-wide main street, staring and seldom smiling as they call out now and then to one another with observations of fleeting

LUREN MCINTYRE

relevance: *"Acho que vou para o mercado antes deles venderem todo o peixe salgado,"* says one with a yawn. "I think I'll go to the store before they sell out of the salted fish."

Rolim de Moura's early spate of murders involved more than drunken brawls. Squatters had moved in on some of the land controlled by big-business interests in São Paulo and other major cities, and when push came to shove, *capangas*, or thugs, hired to do the evicting went about their work with lethal zeal. The squatters, called *posseiros*, were at times equally violent.

Although federal police and other agencies have accelerated programs to control crime and violence, Rondônia continues to wear an aura of apprehension. Much of that has to do with the invasion of Indian reserves by those in search of land and gold. The reserves are so large—one in the southwestern region of the state runs to nearly five million acres—and the tribal populations so small that the trespassers often do not know they are on Indian land, or if they do, they can escape detection for long periods of time. But eventually the clashes occur, and sometimes the brutality is nothing short of a massacre. Some of the Indians, such as the Urueu-Wau-Wau, have made contact with the outside world only in the past 20 years (see the article beginning on page 800).

Before it would approve funding for Polonoroeste, the World Bank set down certain conditions, including the allotment of land for

Swinging into the saddle behind a bag of rice, a young farmer finishes his errand. He has taken his family's rice crop to the mill in Mirante da Serra, which cleaned

WILLIAM ALBERT ALLARD

it and kept a portion as payment. Some settlers ride horses, bicycles, buses, and collective taxis, and a few own cars. Most just walk.

Indian reserves and development of facilities for improved health care for Indians. In effect, the bank was telling the government of Brazil that the country's National Foundation for the Indian, known as FUNAI, would not be allowed to operate as it did in the past, compiling a record of corruption and indifference while serving as the official guardian of Indian welfare in Brazil.

In March of this year word came back to Pôrto Velho that two outsiders had been killed in the Urueu-Wau-Wau reserve by arrows. The bodies were never recovered, and the official investigation amounted to very little. "Even if the Indians did kill the two men and even if we found those who did it, we wouldn't make an arrest," said Wanderley Martins Mosini, director general of civil police in Pôrto Velho. "Brazilian law is designed to protect Indians. They only kill if they are interfered with."

Government officials cite a figure of between 15 and 20 for the number of outsiders believed to have been killed by Indians in Rondônia since the opening of the rain forest for settlement. The number of Indians who have fallen is certainly more. (In one incident this year near the town of Benjamin Constant, in the state of Amazonas, north of Rondônia, 14 unarmed members of the Tukuna tribe, one of the largest in Brazil, were massacred by killers in the hire of timber dealers.)

"THE REAL PROBLEM involving Indians started with the influx of settlers in the early 1970s," Gilio Brunelli told me. Brunelli is associated with Conselho Indigenista Missionário (CIMI), a group with a mission to help the Indians of Brazil.

"The colonization was started by the Brazilian government without any concern for the welfare of Indians," he said. "In 1950 there were as many as 35,000 known Indians in Rondônia, but now we think the population totals something like 5,000. They are dying for many reasons, but mainly because of diseases brought in by outsiders."

Brunelli is free-swinging in his charges that the abuse of the native peoples has at times approached genocide. "There were organized raids to kill Indians and get their lands," he said. "Whole villages have been wiped out. Members of the Zoró tribe, for example, were pushed around and killed by thugs from the town of Ji-Paraná in order to consolidate land for one big rancher."

It is the position of CIMI that nine groups of Indians who have yet to make contact with the outside world remain in Rondônia, hidden in the rain forest. "These are all small families of large tribes," Brunelli said. "As far as we know, there are no big groups without contact in Rondônia."

Near the town of Vilhena, in the southernmost part of Rondônia, there is a FUNAI-run medical station for Indians. There are long lines of people there most every day, waiting to see a nurse or one of the two doctors. On a steamy midmorning when flies and gnats were heavy in the air, Maria do Socorro Souza de Araújo, a nurse, stood on the steps of the single-story wooden building and said, "The invasion of settlers has increased the medical problems among the Indians to a great extent. We lack so many things here now, and I mean just the basic things like bandages and cotton." (There were recollections then of having heard this before, spoken

LOREN MCINTYRE (ABOVE); WILLIAM ALBERT ALLARD

"If it were up to me, I'd leave," says Helena Pereira Stedili, but she has stuck by her husband, Jacinto Luis, who shows off their wedding portrait in the house they built near Alvorada do Oeste. Hoping for more from life than the bottling-factory job he left in Parand state, Stedili has put three years of backbreaking work into their 135 acres. Cutting 40 trees a day with a chain saw, he cleared the land for crops by himself. But his dream is elusive, and Stedili seems discouraged.

by tired and often frustrated workers in medical stations the Third World over, in places all too similar, with the stained, sheetless mattresses in the wards, the bad smells holding their own against the disinfectants, the unceremonious acceptance of death.)

An Indian girl of ten years or so, with blank eyes and a drooping lower lip, raised a broom and made a lazy swipe at the dirt on the steps. Maria do Socorro Souza de Araújo reached out to touch her gently on the back of the neck. "I wish we could do more for her and the others," she said.

THE AROEIRA INDIANS live no more than 30 miles from the medical station, in the northern region of Mato Grosso state, but it is a slow and punishing drive along a narrow track in the jungle before one comes on the clearing where the schoolhouse sits. Of the 121 persons on the FUNAI rolls there, two dozen are of school age, and so for a few hours each day they sit on wooden benches on the open porch, learning to read and spell and make some sense of an outside world few of them have ever seen.

"They have been growing crops on this reserve for more than 15 years now," said Ernane Barros da Cunha, the resident FUNAI agent. "They appreciate farming because this year, for example, they sold 80 tons of rice, and they expect to sell three tons of corn. They also grow coffee, sugarcane, and manioc, in addition to raising some cattle."

It is the custom among the Aroeira to keep half of what they grow and to sell the other half. The money is shared among all. They have remained at peace through the turmoil of the land rush, and, as far as they know, no intruders have moved onto their land. "One of the reasons there hasn't been trouble with prospectors and others coming in here is that the Indians patrol the reserve," da Cunha said. "If they so much as hear an unfamiliar sound, they will go out to investigate."

Pedrinho Manduca, known among his people as Lakrikrussu, is chief of the Aroeira,

and out of earshot of others he will tell you that he has lived in the jungle for all of his 40 years and is frightened silly of snakes. As he was winnowing rice on a mat in front of his thatch-roofed hut, I asked him if he wouldn't rather be hunting and fishing. "Yes, I would," he replied, "but I'm realistic." Still, a day hardly passes that he doesn't send an arrow or two after a bird overhead.

Indians such as those of the Aroeira tribe have a knowledge of the Amazon rain forest far broader than that of anyone else. They know of medicinal values to be found in certain plants, and that is a matter of increasing importance to medical researchers. An Indian whose arrow-tip poison is also an anticoagulant quite clearly is on to something. They know too the ways of the tapir and the three-toed sloth, and they will show you how to take fish without hook and line.

BOTH BY WILLIAM ALBERT ALLARD

Collapsed with exhaustion in the heat and humidity, a hunter lies near the deer he cut down with a machete. He had tracked the animal for four hours after wounding it with a shotgun. Once recovered (above), he holds up the prey that will feed his family. Poor frontiersmen, or caboclos, eke out a living from shifting horticulture, farming, hunting, fishing, and gathering forest products.

And so when our vehicle broke down in the rain forest at a time when night was coming on in a rising chorus of faunal calls and answers carrying down from the great canopy of the trees, da Cunha reassured me. He would blow the horn, and the Indians would hear it and come rushing to our assistance. He predicted their arrival in five or, at the most, ten minutes.

When next da Cunha spoke, it was to say, "I can't understand it."

Three hours later, and still no sign of the Indians (but our fuel line finally cleared), we arrived back in Vilhena, Rondônia's gateway town in the south in time to meet the last arriving bus of the day, bound north on BR-364 for Pôrto Velho.

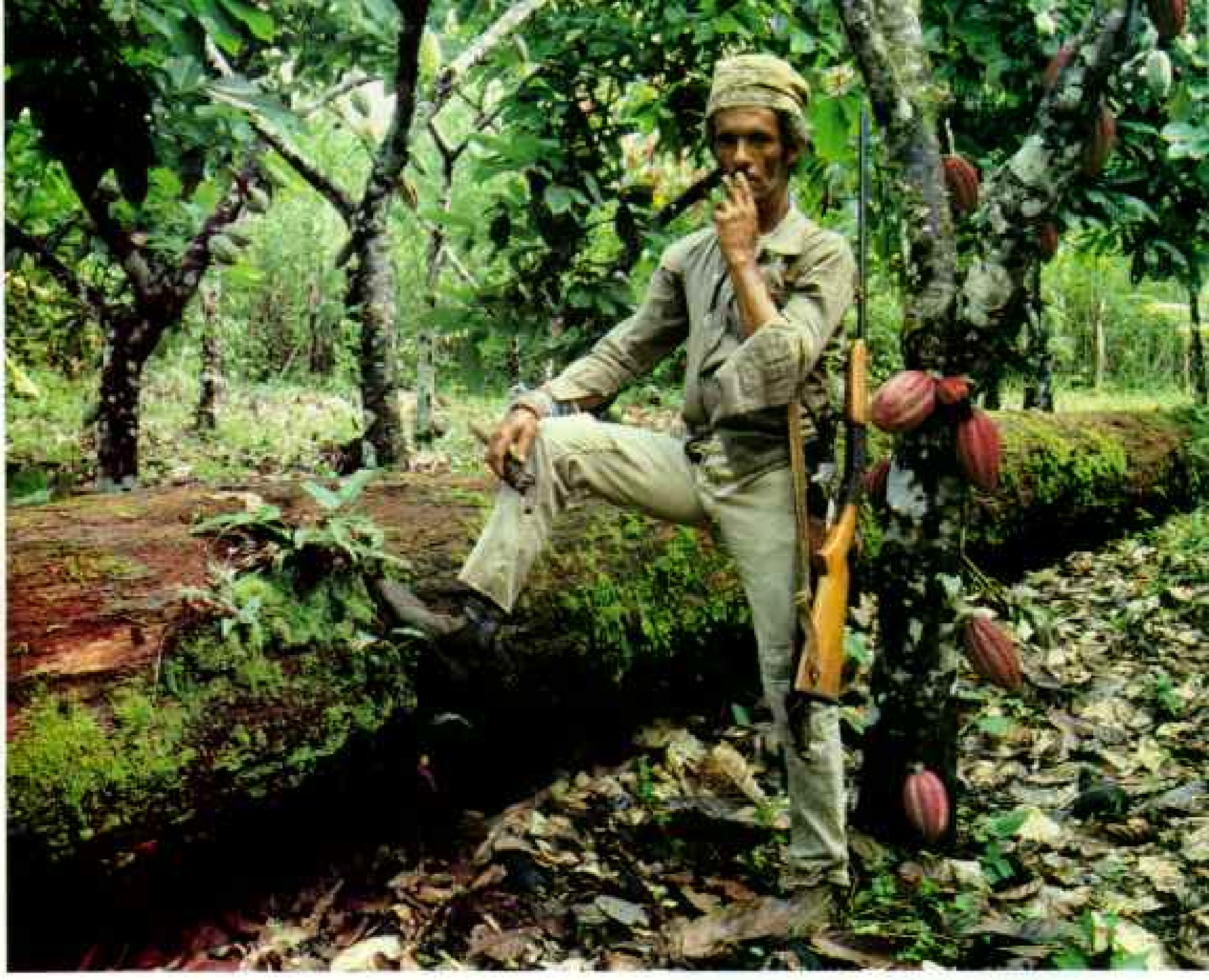
There were procedures here to be followed, and so the bus was directed to a bay in the terminal where the light shone yellow on the concrete and on the masses of large black beetles that lay dead or dying in the gutters. Those among the passengers who were coming to Rondônia with the intention of staying were told that they had to have a yellow-fever inoculation.

"Not as many are coming in now as before," Márcio Pedroso Amorim, a public health worker, said as he prepared to administer the inoculations. "There are still 30 to 35 buses coming through here every day, and most of the people on them are from the states of Paraná and Santa Catarina. Pôrto Velho, Ariquemes, and Cacoal here in Rondônia seem to be the favorite destinations."

A man, his wife, and their three children pulled pieces of fried meat from a greasy paper bag and had their evening meal there on the loading ramp of the bus station. All of them were fair-haired; he said his name was Mayer and that his grandfather had come to Brazil from Germany.

Many Europeans came to Brazil over the past century, some in the wake of wars, stripped of honor and seeking refuge, but most drawn by the lure of what the country could be—the Brazil of tomorrow, the Brazil touted in high-school geography classes the world over as *the* country of the future.

"I guess we won't get yellow fever now," Mayer said, rubbing his arm, "but I never had concerns about health. We're strong, even the children here."



OTHER STRONG PEOPLE have gone into the rain forest and had their strength wasted away like the atrophy of an elm under blight. In 1907, for example, construction of a railroad in Rondônia was started, following several unsuccessful attempts. Five years later the 227-mile-long line was completed, and during that time at least 1,500 workers died.

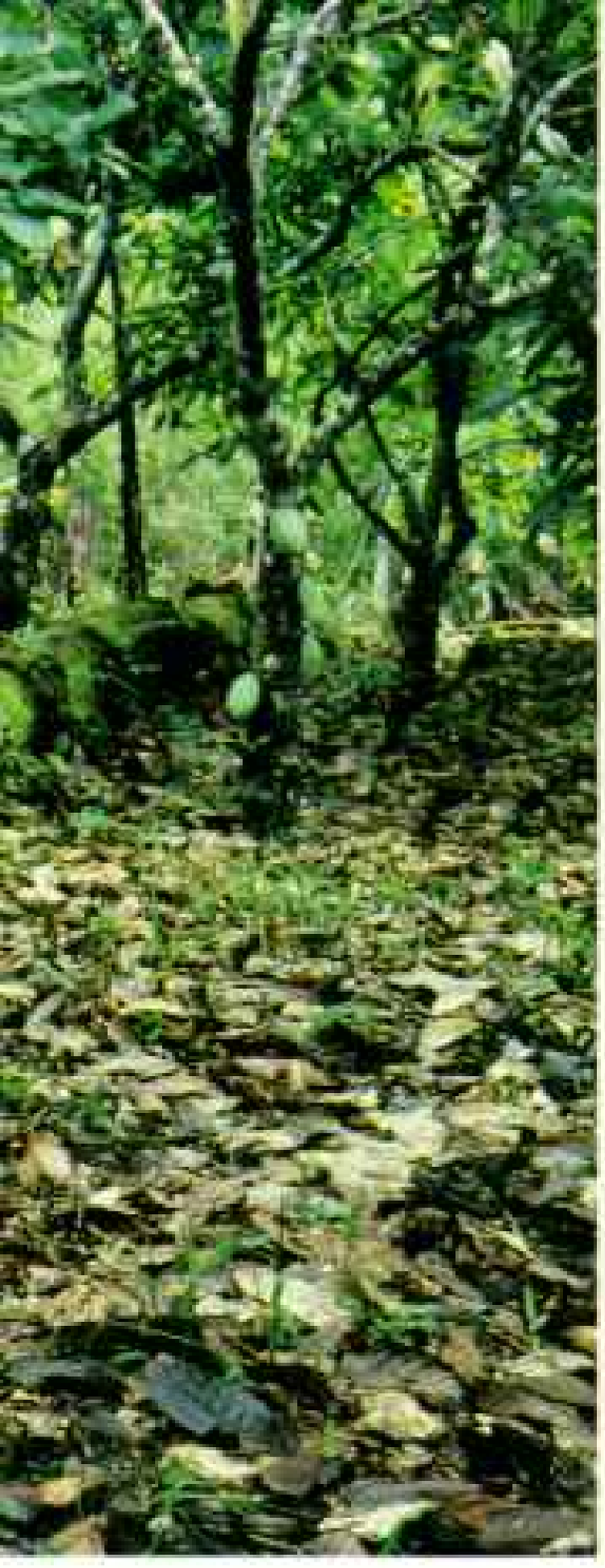
It was called the Devil's Railroad, although the proper name was the Madeira-Mamoré Railroad, taken from the names of the two rivers it linked in order to open the interior of Amazonia for the rubber trade. It was a construction feat with few rivals for its time, attracting workers from 30 countries for the challenge of laying track while under attack from Indians, snakes, army ants, malaria, beriberi, and yellow fever. There were the leishmania too, tiny parasites transporting themselves through the bodies of victims along trails of painful sores. Hospital admissions among the workers during the five years of construction exceeded 25,000.

Pôrto Velho was born of the railroad, and today the three towering water tanks erected by the U. S. company that built the line are still in place, as is much of the original terminal. There is now a museum in the station, and its director, Dionísio Shockness, told me that the new arrivals "have no sense of history, no appreciation of what this railroad has meant to the development of Rondônia."

What is missing from the museum is the golden spike of the railroad. That was removed by company officials at the inaugural celebration. Spike or not, the Madeira-Mamoré Railroad operated until 1972, when it stopped for good.

I went one morning to a place along the banks of the Madeira River where the railroad ran, alongside rapids impassable to river traffic, and I searched for any marks it may have left on the land. But there was nothing except a clearing where swarms of insects hovered over the dead black hen and other items spread out on a red cloth as an offering to the gods of macumba, or black magic. This strain of African origins in Brazil's ethnic character is strong in the Northwest Region.

In those early years of the 20th century,



Full of riches for the taking, the rain forest yields its rubber to a seringueiro, or tapper. Armed against Indians, he pauses in a cacao plantation near Jaru on the way to his trees. When the rains come, he may harvest Brazil nuts, which earn over 20 million dollars in exports each year. Seringueiros in Rondônia and neighboring Acre state have organized to save the rain forest for their extractive activities.

Indians killed a sawmill trucker who had trespassed 15 miles inside the Rio Branco reserve in search of Brazil nut trees. FUNAI agents, police, and the sawmill owner later surveyed the scene. Loggers often take only the forest's most valuable hardwoods.

COLIN MCINTYRE (ABOVE); WILLIAM ALBERT ALLARD

when the railroad was new, the rubber business was king. Although known to Europeans as far back as Columbus, not until more than 300 years later did rubber become a thing of major commercial value. That was due to the development of the vulcanization process by Charles Goodyear. Then John Dunlop patented a pneumatic tire, and in the boom that followed, the price of rubber increased 400 percent. The Amazon basin became as a magnet to tens of thousands of persons.

One of them was Henry Ford. He amassed several million acres of rain forest land (he called it Fordlandia) in order to grow rubber trees and become self-sufficient in tires. But the automobile maker suffered a spectacular setback when a large portion of the plantation was destroyed by leaf blight. The trees were planted too close together, allowing the spores of the fungus to travel from one to another. In virgin jungle the natural spacing of rubber trees keeps leaf blight from spreading. So once again a discordant note had disrupted the fine tuning of the rain forest.

Even before Ford's misadventure in Brazil, Amazonia's role in the world rubber market had collapsed with a shift to Malaysia as the major source. Individual tappers continue to operate in the jungle, however, and with the increasing destruction of rubber trees by settlers, they have begun organized resistance to the practice of slash and burn.

MINDFUL NOW of what must be done if the rain forest in Brazil is not to disappear completely—there are ecologists who predict that it may all be gone by the early years of the next century—Rondônia, in cooperation with the World Bank, has devised a land-use plan for the state. In the areas where the soil is suitable, agriculture will be encouraged.

"Most of the lands that have been cleared have the better soils, and that is good," said Maritta Koch-Weser, an anthropologist with the World Bank's Brazil Department. "It is not correct to say that it was wrong to open up this new frontier. What was wrong was the uncontrolled way in which things were handled. But now, 30 to 40 percent of the land areas in the Northwest Region have

been put into reserves. What remains of the forest outside these reserves must also be saved."

That will not be easy to do, for, as Roberto Ludegaro told me, "You have only to look at the Tubarão/Latunde Indian reserve to see how bad things are here. There is first quality timber on that reserve, and timber dealers, squatters, and even the Indians themselves are cutting down the trees. The government is helpless to stop it because it lacks the personnel to patrol such a large [288,000 acres] reserve."

Ludegaro is a forestry engineer with the Brazilian Forestry Development Institute, a government agency created in 1965 to deal with the problems of deforestation. Like Koch-Weser he holds deep concerns for the survival of the rain forest. Others in the Brazilian government are equally determined to right the environmental wrongs of past years, but they are hampered, at least in part, by tradition.

Traditionally, land barons headquartered in São Paulo and Rio de Janeiro have enjoyed favored treatment. Although the practice is not as blatant as it was during the years of military government in Brazil, office-bound owners are still allowed to buy plots of land from settlers who give up on their attempts to farm. More and more individual plots are being consolidated under absentee ownership, and with money available for fertilizers, grass for cattle grazing is being coaxed from the soil. The largest of these ranches are in the south of Rondônia, not far, of course, from the aortic presence of BR-364.

There is one such place just south of Ariquemes, and it is there that Evandro Pereira dos Santos leaned against the massive delta-shaped trunk of a fig tree and said, "I've been here three years, and I still haven't met the owner."

Pereira, who is 21 and has five children and recurring malaria, is a tenant farmer on the 1,900-acre property. He grows cacao and coffee but says it will all be given over to cattle ranching in the future. "That's why we burned the trees, so we can plant grass for the cattle," he told me. "We've cleared about 150 hectares [405 acres]. It's easy to do if you have a chain saw and a match."

Not many of the new settlers own chain saws. Rather, they set out to prove up the land using axes and hoes. Those who rise above the hardships move from subsistence to cash crops, mostly coffee and cacao. This was the type of agrarian reform that Polonoroeste was meant to bring about—a frontier settler turned successful farmer, happy on bountiful acres amid ripening coffee beans and cacao pods hanging heavy on the branches.

But it happened that diseases were visited on both coffee and cacao, leaf rust on the former and something called witches'-broom on the other.

"We have a big problem in growing cacao," said João Francisco dos Anjos of the State Department of Agriculture. "Chemical control of witches'-broom is too expensive for the average settler, so they mix the good cacao with the bad. As a result, the quality of Rondônia-grown cacao is not first-rate. It sells for less money."

Coffee leads among cash crops, accounting for 60 percent of state agricultural tax revenues. As for the famed Brazil nut, that crescent of meat in a casing harder than teak, it is not among the heavy hitters. "The trouble is the size of the tree," dos Anjos said. "It is too big for the amount of nuts it produces. Attempts are being made now to develop a hybrid tree that's smaller, more fruitful." It would be nice too, he agreed, if they could do something to make the nut more crackable.

NOT ALL NEWCOMERS to Rondônia are interested in land and farming. There is gold to be had, and there are men in the state who have killed to get it. Oftentimes the violence goes unheard and unseen, for it occurs on the bottom of the river, in the deep darkness of the brown Madeira waters. There, groping with suction hoses, divers work around the clock, sending the gold-bearing sands of the bottom up to the waiting boats.

Divers are attacked by other divers in territorial disputes; sometimes air hoses are severed in order to avoid paying commissions to divers. They are like ferries on the Styx, those 50 or so boats, with crews of unsmiling men and women. The machinery for sucking up and treating the sand is noisy and smelly, and set at maximum for industrial hazard.

A quarter hour passed after I went aboard one of the boats before a member of the crew would agree to talk.

"It is very dangerous down there," said

Domingos Sávio. "I've had my air hose cut, so when I dive now, I make sure I know who is working near me." At 28 he has been diving for four years and is hardened to the risks of prospecting in the river. "I came to Rondônia just for the gold," he said. "But no one here gets rich, especially when the river is this high, at 20 meters, and this muddy."

The mercury used to extract gold from the sand is polluting the Madeira at a rate termed critical by a newspaper in Pôrto Velho. The concentrations of mercury in some species of fish have been found to exceed those considered extremely hazardous. Mercury poisoning could cause widespread death among a fish-eating population, but few in Rondônia show more than shallow concern. For the river prospectors it matters only that they can find a shop with a sign that reads *Compra-Se Ouro* (We Buy Gold) and go there with the little cloth bag, heavy with the yellow dust and drawn closed with string.

It is believed that as many as half a million prospectors have joined the gold rush to the jungle of western and northern Brazil, taking out more than 70 tons of the metal each year.

Antônio David de Oliveira sat in a cagelike enclosure at the rear of his store, just beyond the shelves holding boxes of soap powder. Only minutes before, he had purchased nine grams of gold from a river prospector for a price of $160. "When I get a kilogram, I send it off to São Paulo for sale there," he said. "Less gold is coming in now. I think that the boom is not so big any more."

Away from the Madeira River there are some 5,000 prospectors seeking gold near the highway town of Jaru. Thousands more search the jungled interior for cassiterite, or crude tin ore. Rondônia claims to have greater cassiterite reserves than anywhere else in the world. But they are not easy to get to.

The way to some of the richest deposits lies out of Ariquemes, going west for around 50 miles. The journey by car takes a day, sometimes two. There is a village there, a place that Mélio Cavalcanti described to me as "A mess. Lots of whiskey and women."

Cavalcanti has been mining for tin ore in the region for six months. In a good week he will take out as much as 6,500 pounds of rock for processing. "There are more than 15,000 prospectors," Cavalcanti said, "and still there is plenty of ore for all. The trouble is getting there. The mud is up to the knees, and that's not even in the wet season."

He predicts that the cassiterite there will run out in four or five years. By then, when the last prospector walks away from that place, the government's land-use plan will have been tested and, if successful, will have brought some structure to Rondônia, such as zones for agriculture and ecological reserves. And no longer will the end of the dry season be announced by the smoke of more than 70,000 square miles of Amazonian trees and other tropical growth set afire.

That's if it is successful. Otherwise, the ghost bus to El Dorado seems destined to break down for good somewhere along BR-364. □

WILLIAM ALBERT ALLARD

Country-butter blonde Bernice Strêge has suffered a dozen bouts of malaria in the year and a half her family has lived near Ariquemes. Settlers count such attacks among the many rigors of the frontier.

"Their innocence is as great as Adam's," reported Portuguese explorer Pedro Álvares Cabral of the first Brazilians. Blown too far west on a voyage to India in April 1500, his fleet anchored off an unexpected shore where the people seemed as beautiful as birds. Reports such as his from the New World fostered the idea in Europe of a "noble savage" living in harmony with nature.

In 1986 a hunter named Moãgana (right) guided me to his hamlet in the rain forest of Rondônia. His gentle ways belied his reputation for slaying diamond prospectors. He gave me a wristlet of carved beads to increase my strength. Last December he died in the forest, possibly of snakebite. I still wear the wristlet in remembrance of his smile.

"Last Days of

By LOREN McINTYRE Photographs by W. JESCO VON PUTTKAMER

LORES MONTES

Eden”

Rondônia's Urueu-Wau-Wau Indians

To celebrate the killing of a rubber tapper who encroached on their indigenous lands, Urueu-Wau-Wau villagers perform a victory dance. Because their territory is off-limits to outsiders, the warriors face no reprisals from the government. At the point in the dance

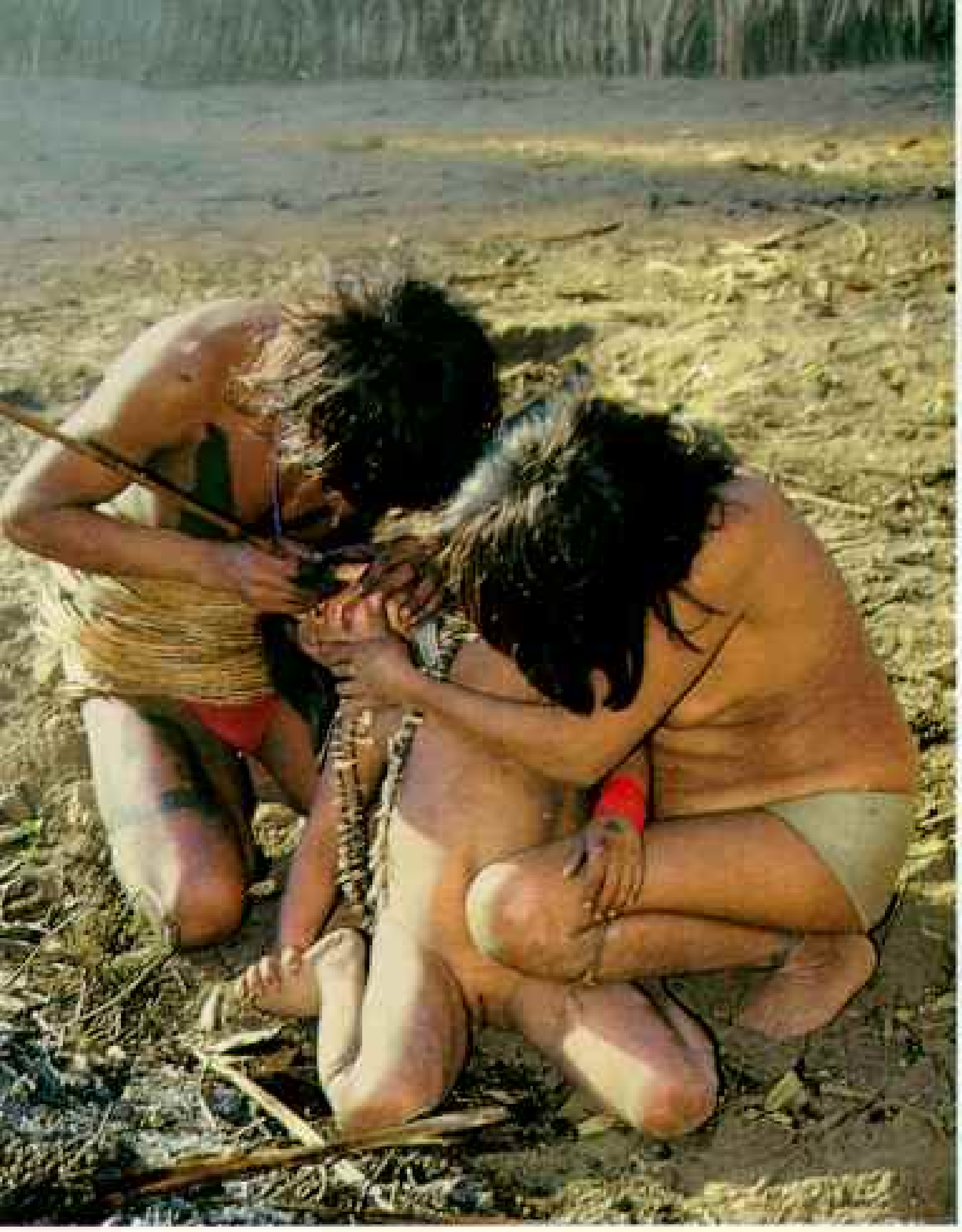
LOREN MCINTYRE

where "hunters return from the kill," women and often children join in. Then all stand and watch the warrior reenact his victory. Letting the bowstring twang, he shouts a war cry and screams as an imaginary arrow penetrates the victim's heart.

JON SCHNEEBERGER, WILD STATE

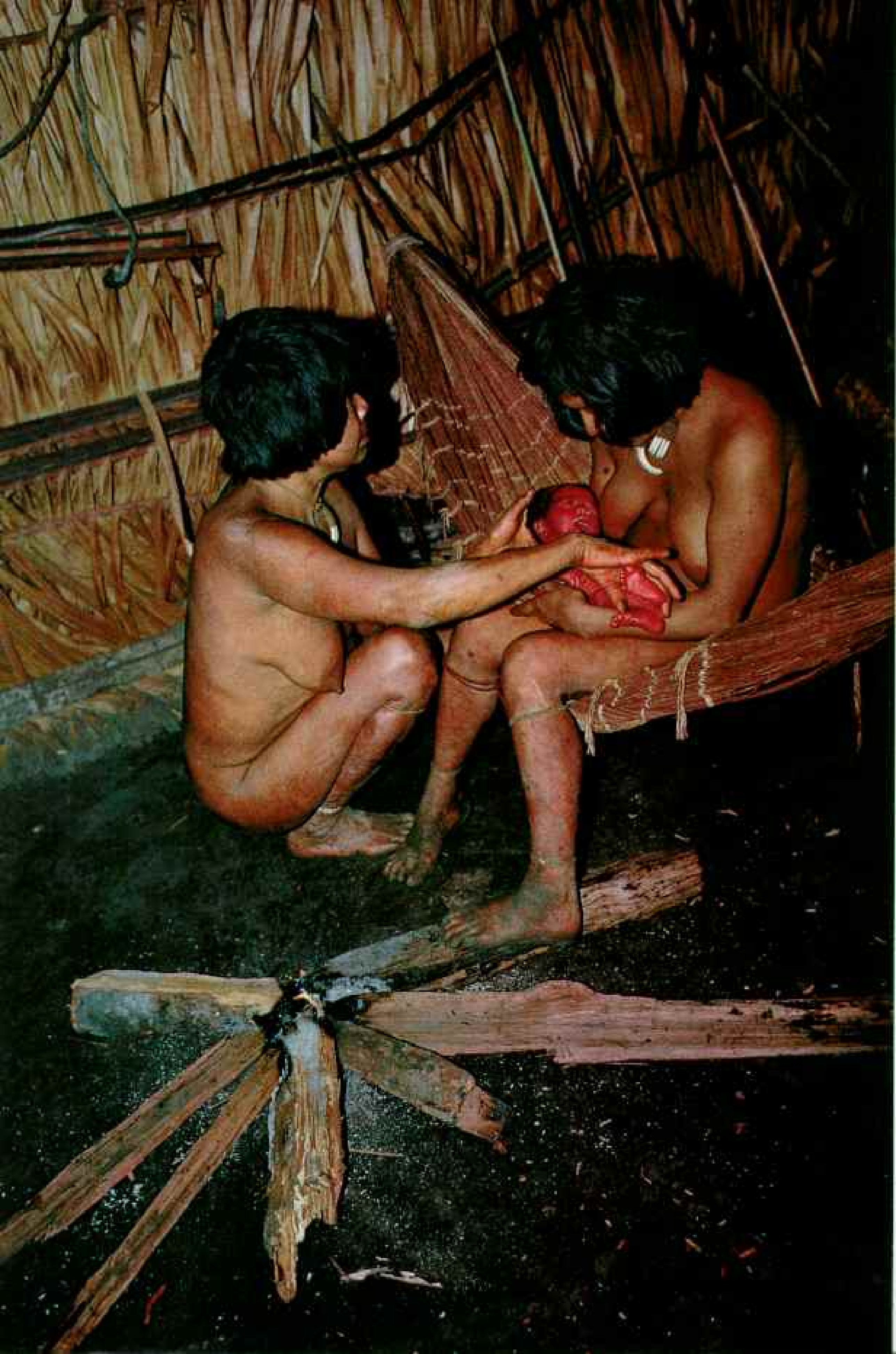
Captivated by her own image, an Urueu-Wau-Wau girl studies a plaything from another world at an outpost of FUNAI, *Brazil's National Foundation for the Indian. Offering medical aid, such outposts are the Indians' only official contact with the outside. Her forehead decorated with the juice of the* **genipap**, *a tropical fruit, Adiwu, the wife of headman Djaui, reflects the dignity of her position.*

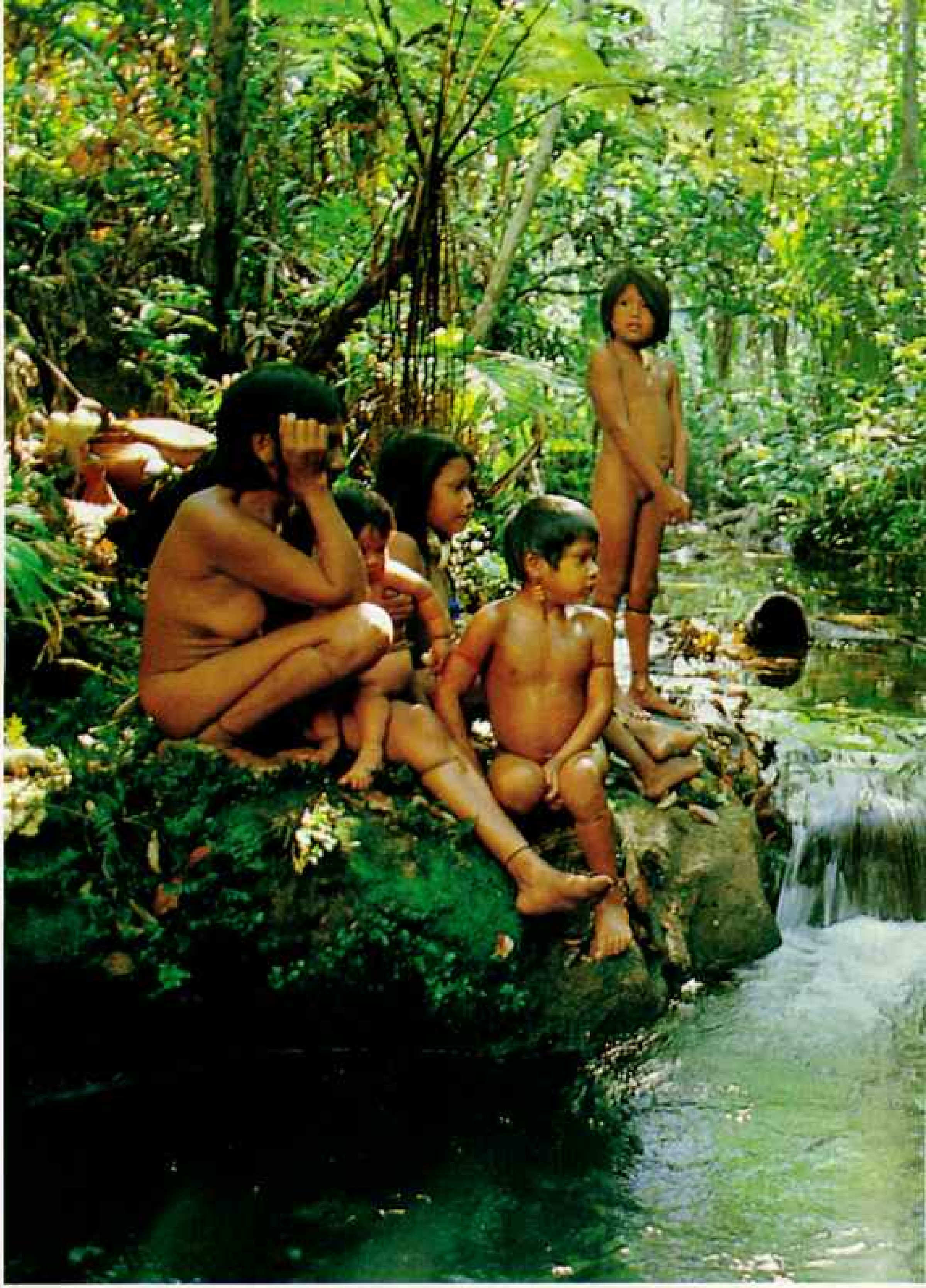
Secrets of rain forest chemistry provide a feast for the Urueu-Wau-Wau. Using poison arrows, they down a young tapir that bumbled into their village at night. Wooden arrow points are coated (below) with sap squeezed from the stringy red bark of tiki uba *trees and hardened by fire. An anticoagulant, tiki uba causes victims to bleed to death. In addition to such deadly jungle lore, knowledge of potentially useful foods and drugs, accumulated over thousands of years, may be lost forever if the forest and its inhabitants disappear.*



A teenage dental surgeon (left) pries a tooth from his little sister's mouth, while their mother restrains the wailing patient. Holding the memento afterward, the girl wears necklaces of many other kinds of teeth, illustrating the Urueu-Wau-Wau propensity for extracting them from capybaras, jaguars, monkeys, wild boars, and settlers' dogs to make jewelry.

A midwife (right) helps Mandé-i anoint her newborn son with urucú, a red vegetable dye, for good health and appearance. His cradle will be a hammock of tucum palm fiber filled with clean white sand laid over wild banana leaves. Native lore and rain forest remedies have failed to safeguard the Urueu-Wau-Wau against the onslaught of Eurasian and African diseases. Even now they die of measles and influenza.





Keepers of the headwaters, Urueu-Wau-Wau youngsters bathe in one of the myriad sources of the Amazon, watched over by a concealed warrior and indulgent mothers. The boys and girls swam well, but to my surprise an

LOREN MCINTYRE

older woman was about to drown until I came to her aid. In the past the fierceness of the natives has protected the heart of Rondônia from deforestation. Now Brazilian law declares inviolate this land once compared to Eden.

The End of Innocence

THEY AVOID eye contact during serious powwows, a practice I've seen in other Amazon tribes. This time the subject could not have been more serious: to kill or not to kill the strangers in their midst.

The naked warrior with necklaces of boars' tusks, Canindé, and the headman in the red shirt, Djauí, chant in ritual argument. Djauí repeats over and over in the Urueu-Wau-Wau tongue something that sings like this: "They offer knives and axes, and clothes for bitter nights. They chase away the miners. The strangers are *catú*—they are good."

The strangers he approves of are *sertanistas*, or frontiersmen, of FUNAI, Brazil's National Foundation for the Indian, who have come to prepare these natives of Rondônia for the unwanted arrival of civilization. A Parintintin Indian interpreter listens to Canindé's contrapuntal reply, chanted simultaneously. It is a single repeated phrase: "Let me kill. Let me kill."

The sertanistas see Canindé as an archetypal rain forest warrior. He carries a .38-caliber bullet embedded in his left arm and shotgun pellets in his back. He has slain numerous invaders and would send many an arrow winging if he could corner Alfredão, the rubber tapper who kidnapped his mother and little sister a decade ago. Alfredão kept Canindé's sister to serve him; she became his unwed wife and bore his children.

And then there is the backwoodsman Atanásio, the "green man," a jaguar hunter who says he burned Canindé's village and escaped by staining himself green with mashed leaves of a jungle vine, so not even wild beasts could see or smell him. In Indian territory he takes the extra precaution of repeating backwards two prayers, "Saint Cicero" and "Hail Mary."

The powwow is taking place outside the blue plastic visitors tent at Alta Lídia, a Brazilian government outpost in the central highlands of Rondônia. Alta Lídia is an "attraction front" set in the middle of Urueu-Wau-Wau territory as a base for "pacification" of the tribe. Its small staff of ill-paid sertanistas includes Indians of other tribes who hunt food and help make contacts. It took many gifts to coax Djauí out of the rain forest. His "defection" may have been influenced by his mixed Indian-Caucasian ancestry, evinced by his bald head and white whiskers, both uncharacteristic of Indians. Kidnapping is not unknown among the Urueu-Wau-Wau, and Djauí may have been captured as an infant or may be the offspring of a captive.

Well before Canindé's arrival, the FUNAI people had come to regard as friends the warriors who hung around camp. But one morning three bowmen shot at Bahiano Maia, the FUNAI agent in charge. An arrow pierced Bahiano's lung. When nurse Maria Vandy pulled the

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This is the 14th GEOGRAPHIC byline for free-lance writer and photographer LOREN MCINTYRE. His last article, "The High Andes," was published in April 1987.

arrow out, blood spurted an arm's length. She stanched the wound, and for once the solar-powered radio got through to headquarters at Pôrto Velho.

"We sent a plane and saved Bahiano, though he was later gunned down in town by a drunk," said Apoena Meirelles, then FUNAI director for Rondônia, who quickly took charge at the Alta Lídia shelter. Apoena is a famous sertanista, as was his father, Francisco. FUNAI's bureaucrats in Brasília disparagingly call him Jungle Jim.

Everyone began to wear sidearms after the incident. No one expected to fire at anything but the sky, but neither was anyone eager to exemplify the motto coined early in this century by army officer Cândido Rondon, the great champion of Indian rights for whom Rondônia is named: "*Morrer se fôr preciso, matar nunca!*—Die if necessary, but never kill!" Every sertanista kept a flashlight near his hammock and a tin can as a urinal, because Apoena allowed no one to venture outside after dark. "The Urueu-Wau-Wau love to make necklaces of primate teeth," he cautioned.

APOENA'S FRIEND Jesco von Puttkamer, Brazil's legendary chronicler of Indian contacts, kept a camera hanging on the palm-slat wall. A peephole let him secretly photograph any goings-on outside. Into every other chink and crack in the wall that a swift arrow might enter, Jesco had stuffed pieces of pasteboard.

One day a lookout in a tree called "*Urueu vêm! Urueu vêm!*—They're coming!" It was Canindé and his warriors. Djauí walked out to meet him. Jesco photographed them (preceding pages) through his peephole.

In time the chant ran down, and it was clear that Djauí had prevailed. For five centuries the Europeanization of South America has been abetted by Indians who have sided with better-equipped intruders—conquistadores, priests, slavers, ranchers, and government agents—in the subjugation of other Indians.

FUNAI's Indian employees were soon dancing and exchanging gifts with Canindé's warriors. That night, while Jesco was telling his diary, "How beautiful are the Urueu-Wau-Wau, people from a star," Canindé's young men tried to set fire to the camp, but the thatch was wet. That was the last time the Urueu-Wau-Wau threatened Alta Lídia. Nearly all of them now recognize FUNAI's agents as benefactors, though not very powerful ones.

Indian children at the post who are learning Portuguese report that Canindé changed his name last year to Tarí; next year it could be Apoena. The Urueu-Wau-Wau often name themselves anew after someone they like. Canindé has no identification card to prove he is a Brazilian citizen. Without a legal name, without credentials, he could not vote for a champion of Indian rights even if he knew how. His vote, at any rate, would not carry much weight. Settlers outnumber aborigines 250 to one in Rondônia.

Somewhere in the forest Canindé sharpens hardwood arrow points, while somewhere else a rubber tapper jokes nervously about fastening rearview mirrors to his hat. Canindé slings his hammock in one of several lean-tos strategically hidden within 7,000 square miles of primeval forest reserved for his small and scattered tribe. An official population estimate is 1,200, but so few dwellings have been sighted on overflights that I think fewer than 350 Urueu-Wau-Wau actually survive.

I see Canindé's people as

Flight deck anchored in an emerald sea, the Jamari outpost is one of four "attraction fronts" allowed inside Urueu-Wau-Wau hunting grounds. All were launched by Apoena Meirelles (right, at center without hat), a former president of FUNAI, to "pacify" and protect Indians from civilization. At Apoena's side, in white cap, stands Jesco von Puttkamer, who has chronicled and photographed Indian life for NATIONAL GEOGRAPHIC for two decades.

LOREN MCINTYRE (TOP)

elusive wraiths in Rondônia's rain forest, an enormous green cage that encloses the tribe. Long isolated in mid-continent, Canindé's ancestors escaped imported diseases and slave raids that wiped out 90 percent of the Indians in Brazil. The tribe's containment began in 1776 with construction of a great Portuguese fortress on the Rio Guaporé to the south (map, pages 778–9). In 1872 railroad tracks began to mark the Urueu-Wau-Wau's northwestern boundary. A road slashing through the heart of Rondônia in 1960 formed a northeastern border. The road became a conduit for contamination of the ecosystem, like a dirty thread left in a wound. It is now a paved highway, BR-364. Side roads complete the encirclement of the tribe, and pioneers are laying charred rectangles of cities-to-be on the natural curves of the Indian land.

A Rondônia map of "killing sites" reveals 45 Indian attacks and eight by gunslingers since BR-364 was begun. Yet the name Urueu-Wau-Wau never made the evening news until 1979, when Indians killed two children of Francisco Prestes and kidnapped his son, Fábio, age seven. Prestes was building a homestead on Indian land mistakenly allotted him by the federal government. The kidnapping generated so many armed search parties that FUNAI was obliged to try to pacify the Urueu-Wau-Wau before vengeful settlers covertly warred on them. The boy was never found.

"Two years after we built Alta Lídia and hung presents in outlying shelters, arrows stopped flying and the first peaceful Indians approached, Djauí among them," Apoena related. "Bahiano Maia, my agent in charge, took off his clothes to prove he was hiding no weapons. The Urueu-Wau-Wau grabbed gift machetes and ran. Bahiano was jubilant, but I felt *saudade*, heartache; each time Indians come for presents or medicines, a little of their freedom slips away."

JESCO VON PUTTKAMER joined Apoena and stayed close to the Urueu-Wau-Wau for six years to collect material on the tribe. He had begun contributing to NATIONAL GEOGRAPHIC by illustrating an article on Brazil's Stone Age tribes in September 1968. Working with Apoena—who later became FUNAI's president—and supported by the Catholic University at Goiânia as well as the GEOGRAPHIC, Jesco has sought out hidden tribes one after another before their candor was corrupted by outsiders, "while they still perfect are." He realized that his presence provoked change, yet he hurried to get there with his diary and cameras ahead of missionaries and anthropologists, ahead of the bulldozers that uproot both earth and innocence.

Jesco mourned the passing of the Indians' natural nudity, saying "O Loren, they're not perfect any more." Yet he brought them shirts and shorts. To call on Indians with Jesco meant lugging machetes, fishhooks, aluminum pots, baseball caps, flashlights, and mouth organs. We'd reach a village on foot or by jeep, boat, or plane—but a sleigh drawn by reindeer would have been more appropriate. Indian kids came running and piled onto the knees and into the embrace of this Santa Claus in mufti, "Borbula," their friend with the "great moon face." His bag soon empty, Jesco would give away his personal belongings, one by one, then turn to me in mock despair. "O Loren, you must befriend Parica, this very powerful warrior. He will love to try on your shirt." I wished for elves.

Jesco's wooing of Indians with gifts has impeccable antecedents. Columbus carried ashore in 1492 not only the cross and sword of conquest, but also caps, beads, and hawkbells that delighted nude young men with painted bodies much like the Urueu-Wau-Wau today. And the conquerors quickly learned that once hooked on steel, the Indian cannot do without.

By 1986 Indians had allowed FUNAI nurses to visit two distant villages and treat patients near death from pneumonia, malaria, and snakebite. Diabetes and a bad foot kept Jesco from going along. "I felt sad, but a young prince, Djauí's son, helped me gather the sap of *tiki uba* bark, an anticoagulant used on poison arrows. I think it may be a great pharmaceutical find."

I went instead, unarmed, and followed Urueu-Wau-Wau guides 11 hours along hunting trails as roundabout as any on a treasure map—a suicidal trek in earlier years. In the green labyrinth without horizon I came upon a naked bowman crumpled in the leaves and shuddering with malarial chills. I made him take my chloroquine. When I slipped and grabbed at the barbed aboveground roots of a *paxiuba* tree, thorns gashed my palm long and deep enough to confuse a fortune-teller.

At the hamlet I exchanged gifts with the headman, Moãgana (pages 800-801). Adults danced to celebrate killing a rubber tapper. A child carried a red macaw, emblem of the tribe, on a tall pole. Another tethered a huge morpho butterfly with a thread and flew it like a kite of burnished blue. In the evening girls played at putting fireflies in their hair. The night was so cold that two fires beside my hammock were not enough.

The full moon stood at zenith when I awoke. A warrior was

pacing back and forth, repeating a four-note chant and brandishing his long bow and a clutch of longer arrows. Heedless of me and my tape recorder, he drew his bow, let the bowstring twang, and shouted a war cry, sending the ghosts that cause nightmares to the moon. Then he went on pacing and chanting.

A jaguar's caterwauling spilled hunters out of their hammocks. Borrowing my flashlight, they ran into the dark woods to shoot it, but the jaguar got away. Next day they hunted toucans and monkeys to roast. I ate none lest they kill more on my account, although the forest seemed full of game. A woman put on a T-shirt silk-screened with dirty words in misspelled English. I learned that Indian boys had brought it from a tin mine where gifts were greater than FUNAI's and where they learned to curse in Portuguese.

To see where Jesco's "young prince" might step through the looking glass into modern-day Brazil, I slogged all day through knee-deep muck to reach a tin strike that was advancing into Indian lands. At Bom Futuro (Fine Future), about 50 miles from BR-364, thousands of placer miners were sluicing the soil of the forest floor under the canopy (pages 788-9). In their frenzy and disregard for law and order they left victims of nocturnal shoot-outs to cook in the sun. State police recently raided Bom Futuro to disarm the miners but failed to find the guns they had hastily buried in plastic bags.

From concealment Uarimã (right), warrior son of bald Djaui and handsome Adiwu, watches with apprehension the miners' inroads. Although he is armed to the teeth, Uarimã's powerful jaguar-tooth amulet sash and bow and arrows are no match for firearms.

LAST MARCH I dined with Orlando Villas Boas, a sertanista often mentioned with his brother, Claudio, for the Nobel Peace Prize. With an almost mystical empathy for natives of the forest, they spent 40 years trying to postpone encroachment upon Brazilian Indian culture. Orlando insists that "an integrated Indian is no longer an Indian but just a lesser citizen of the Brazilian nation."

As Brazil's population has quintupled in his lifetime, Orlando feels that the westward tide of white and black humanity is hopelessly inundating the Indians of the rain forest. "All we can do," he says, "is pick up the hat of a drowning man and marvel that we lived to witness the last days of Eden." □

At home in the boardroom as well as in the wild, the Nature Conservancy is striking deals to preserve the earth's biological diversity.

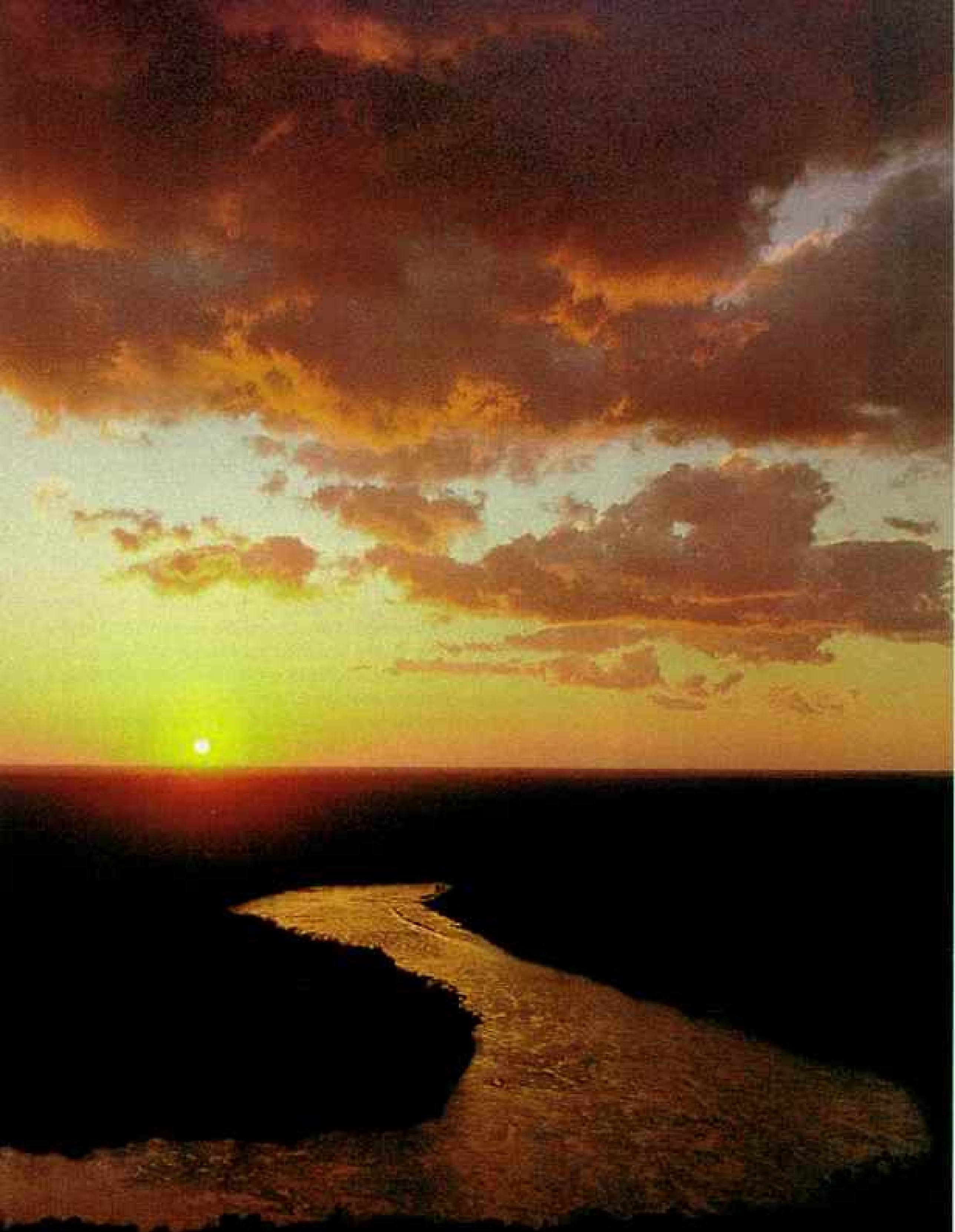
QUIETLY CONSERVING NATURE

By NOEL GROVE
NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by STEPHEN J. KRASEMANN

ON THE RUN FROM MAN'S ENCROACHMENT, the San Joaquin Valley kit fox has found a home. To protect the fox and other locally endangered or threatened species, the Nature Conservancy bought nearly half of the 180,000-acre Carrizo Plain, 150 miles northwest of Los Angeles. Now also under federal protection, the land is the last significant stretch of native grasslands that once covered California's great Central Valley.

The private, nonprofit Conservancy—using a business-like rather than confrontational approach—has set aside 3.5 million acres in all 50 states in the past 37 years. Its goal is to save plants, animals, and their habitats from extinction. With a private foundation loan and a corporate gift the group acquired more than 64,000 acres of wetlands in the Big Bend area of Florida, adjacent to the Suwannee River (following pages).



EARTH '88

"Virtually all students of the extinction process agree that biological diversity is in the midst of its sixth great crisis, this time precipitated entirely by man."

—EDWARD O. WILSON, Harvard University

BUTTON-SIZE ROSETTES bloom on a patch of Knowltons cactus, a plant so rare that collectors pay $100 for a single seed. To protect it, the Conservancy will not disclose the location of its habitat.

Mexican free-tailed bats pour from Brucken Cave near San Antonio, Texas. The colony, numbering 20 million or more, is the world's largest known concentration of mammals. The Nature Conservancy has helped Bat Conservation International and the property owners, the Marbach family, protect the site, which had been mined for guano.

STEPHEN J. KRASEMANN WITH GEORGE VON SANTON, NGS STAFF (OPPOSITE)

IN THE SHIRT-STICKING HEAT of south Florida I joined two men on a treasure hunt. Pushing through thick mangrove, knocking down spiderwebs that made the skin crawl, we sought a prize that could be more precious than gold.

"There!" Biologist Mark Robertson pointed triumphantly at jade spires eight feet tall, thick as my forearm and bristling with spines. "Found in only four other locations in the United States," he added.

Key tree cactuses, *Cereus robinii*, they rose slim and straight from the leaf litter like exclamation points, punctuating their near extinction. "They're great!" shouted John Cook, a man experienced in real estate. "Let's go after them!"

Going after them meant finding a way to make sure the prickly plants remained undisturbed. The chances for preservation of this clump were not good. A few hundred yards back we had passed several large earth-moving machines, poised to devour this section of coral and sand to use elsewhere as landfill.

Little studied, probably never tested for its possible benefit to mankind, the Key tree cactus could hold some herbal clue to the adaptability of plants to arid regions. We noted that it reproduced by cloning, new plants rising out of previous ones downed by wind. Perhaps its sap held a cure for victims of some dread disease. At the very least, it was an eye-catching sculpture that captivated the three of us, yet stood in danger of disappearing forever.

Preventing that was foremost in the minds of my two companions, workers in the Nature Conservancy (TNC). One of the youngest, least known, and most successful environmental groups in this country, it combines talents in biology and business to save any species or biotic community from extinction.

With the clump of rare cactus found and identified, the Conservancy might try to buy the land to establish a preserve or resell it to a federal or state agency that would protect it. If the owner would not sell, it might seek a conservation easement—a legal agreement that in exchange for tax benefits no activity would ever be undertaken there that would harm the endangered plant.

Buying, selling, trading, cajoling, the Nature Conservancy has brought protection to three and a half million acres in the United States and adds an average of another thousand acres daily. It maintains a million and a half of these acres in about a thousand TNC preserves, the largest private sanctuary system in the world. Biggest is 55,000 acres on Santa Cruz Island off the California coast (pages 834-5); smallest is nine-tenths of an acre of Connecticut marsh where herons feed. Thousands of acres more, bought by the Conservancy, have become *(Continued on page 828)*

Saving corners of wilderness

FOR MAN's benefit as well as nature's, the Conservancy constantly finds new species that need protection and promising lands that may yield others. Plants and animals—some yet to be discovered—may prove invaluable in combating disease, as has the blood of the horseshoe crab in the diagnosis of meningitis and bee venom in arthritis treatment.

Founded in 1951, the organization has more than 435,000 members, and chapters and field offices cover every state. The Conservancy is criticized by more outspoken environmental groups. Some fault it for declining to lobby for legislation. Others see any corporate contribution as necessarily tainted. Yet by using its chief tool, the checkbook, the organization has built the largest private sanctuary system in the world.

As part of the Conservancy's international program, the Latin American Division is developing data bases for nine countries—information shared within the Conservancy's headquarters near Washington, D. C., where a computer center tracks the status of 50,000 species. In Canada rare and endangered species are being identified in partnership with the Conservancy, the first step in the land-acquisition process.

Agate Desert Preserve

Found on a protected 49-acre preserve in Oregon's Rogue Valley, the rare big-flowered woolly meadow-foam produces an oil usable for pharmaceutical products and as a machinery lubricant.

Dancing Prairie Preserve

Managed by the Conservancy, a 160-acre stretch of Palouse bunchgrass prairie is the last known breeding site remaining in Montana for the Columbian sharp-tailed grouse.

Carrizo Plain Reserve

Managed by the Conservancy and government agencies, this grassland provides habitat for the San Joaquin Valley kit fox and other species.

Ruby Valley

Surrounding Franklin Lake on a spur of the Pacific flyway, this 9,500-acre area provides resting and feeding ground for more than 200 waterfowl and shorebird species and breeding ground for the trumpeter swan.

INTERNATIONAL PROGRAMS

- Computerized biological inventory center
- Partner organization

NGS CARTOGRAPHIC DIVISION
DESIGN: NANCY SCHWEICKART
RESEARCH: KAREN F. FALCONER, ROSA M. LARRAGA; PRODUCTION: NANCY L. CLAPSADDLE
MAP EDITOR: JOHN T. BLOZIS
ART: CHRISTOPHER A. KLEIN

Lock and Dam No. 14 Eagle Preserve

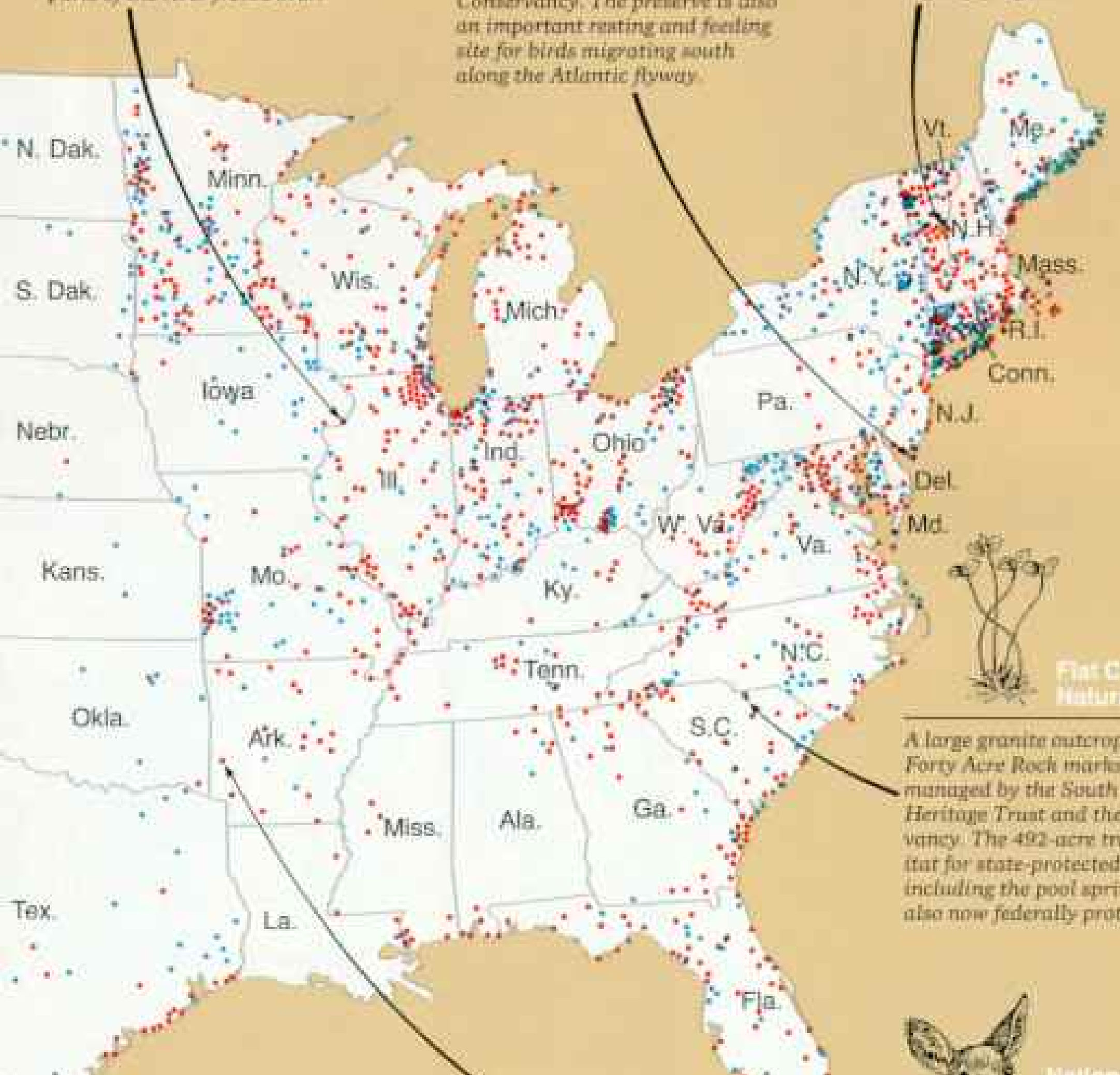
Managed by the Conservancy and Scott County, Iowa, a seven-acre tract with a stand of cottonwood trees provides habitat for endangered bald eagles. The birds feed on fish as they pass over spillways, a particularly important source of food during the winter when other parts of the river freeze over.

Cape May Migratory Bird Refuge

The piping plover and other endangered birds breed in a protected area of 379 acres managed by the Conservancy. The preserve is also an important resting and feeding site for birds migrating south along the Atlantic flyway.

Tiger Beetle City

Proposed for federal designation as an endangered species, the cobblestone tiger beetle inhabits a five-acre tract along the Connecticut River, one of some 3,000 privately owned sites voluntarily protected under the Conservancy's registry program.



Flat Creek Natural Area

A large granite outcrop called Forty Acre Rock marks this site, managed by the South Carolina Heritage Trust and the Conservancy. The 492-acre tract is a habitat for state-protected plants, including the pool sprite, which is also now federally protected.

National Key Deer Wildlife Refuge

The Conservancy is adding more prime habitat to the existing 7,500-acre refuge to protect the Key deer, the smallest deer native to North America. Fewer than 300 of these animals remain in the world.

Cossatot River

The threatened leopard darter and other animal and plant species exist only in the region of the Cossatot River State Park and Natural Area, managed by Arkansas state agencies.

Lower Rio Grande Valley

The endangered ocelot (above), jaguarundi, and peregrine falcon inhabit 2,233 acres of palm jungle and brushland bought by the Conservancy and turned over to the U. S. Fish and Wildlife Service.

0 300 km
0 300 mi

NATURE CONSERVANCY PROGRAM

Preserves are owned by the Conservancy and managed by staff and volunteers working out of state field offices.

COOPERATIVE PROGRAM

Protective restrictions often accompany land transferred to government agencies, universities, and other conservation groups.

A WELL-KEPT SECRET *for 14 years, Kartchner Caverns contain Arizona's largest known cave column (left, at center), here being viewed by Randy Tufts, wearing a dark shirt. Tufts found the opening in 1967 and, with fellow spelunker Gary Tenen, discovered the caverns in 1974.*

The cave's existence was revealed to the Kartchner family, who own the ranchland above it, in 1978 and to the state and the Conservancy in 1985. Despite the apparent absence of uncommon flora or fauna, the Conservancy acquired an option to buy the land to preserve this geologic rarity. The 2.5-mile-long cave houses some of the world's longest "soda straws," fragile stalactites often as thin as their namesake. Seldom more than a foot or two long, one here reaches 22 feet.

Approaching one of the chambers, Arizona parks employee Rafael Payan negotiates a muddy crawlway with camera gear.

STEPHEN J. KRASEMANN WITH LARRY D. KINNEY, NGS STAFF (LEFT)

state and national parks and wildlife refuges. An international program also protects species and ecosystems in Latin America.

Although many purchases turn into public lands, recreation and aesthetics are by-products, not the primary goal. "We're in the science business, not the pretty business," says TNC president Frank Boren, who looks, and sometimes acts, like a silver-haired football coach. "Our mission is very focused. We are preserving biotic diversity in the world."

The "ark" TNC is building includes both plants and animals. Hundreds of this planet's species have proved valuable to mankind. The *Polyzonium* millipede found in American beech-hemlock forests carries an insect-repelling odor that might be transferable through genetic engineering to cereal crops. A gene

DINING AND DEALING: Principals in the Kartchner Caverns acquisition chat with café owner Lorene Whaley in Benson, Arizona. Seated, from left, are co-owner Puul Kartchner, Ken Travous, director of the state parks department, Dan Campbell, head of the Arizona Nature Conservancy, Randy Tufts, Benson Mayor Jim Mellentine, Gary Tenen, and Dean Kartchner. The state this year agreed to buy the Conservancy's option and plans to allow carefully monitored public access to the caverns by 1993.

found in wild Mexican beans can make stored edible varieties resistant to weevils, which destroy much of the crop in the Third World. Wasp wings were studied by a California engineer because they are aerodynamically more efficient than the wings on airplanes.

A quarter of all prescription drugs—worth more than 15 billion dollars annually in the U. S.—include plant extracts. An ingredient from the Madagascar periwinkle contributes to a 95 percent chance of remission for victims of lymphocytic leukemia—usually children. Extracts from wild yams provide an active ingredient in birth-control pills. A material in the shells of certain crustaceans and insects can be made into surgical suture thread that dissolves in a sewed-up wound and promotes its healing.

The Conservancy shelters half a dozen species showing laboratory promise, but emphasis is on saving not the profitable but the unproved. Said the organization's chief scientist Robert Jenkins: "We may be discovering infinite value in obscure species over the next century, but the real urgency now is to save them."

Only one in every hundred known species has been intensively

screened for potential use. Science remains uncertain as to how many plants and animals inhabit this planet, but millions may become extinct before they are even identified. In her book *State of the Ark*, zoologist Lee Durrell estimates that by the year 2000 man's activities may have cut down, plowed up, paved over, or otherwise crowded out one in five of the species that remain.

IN THE FACE of such losses the Conservancy has devised a plan for inventorying biota and rescuing those in danger. The Heritage Program, first applied in South Carolina in 1974, proved so successful that similar programs now exist in every state but Alaska and Alabama, as well as the District of Columbia. All were created as joint ventures between the states and TNC. Today more than half of the states pay their own program costs, but TNC trains all staff—nearly 300 people and growing.

In a given state, botanists, zoologists, and ecologists check on the status of plant and animal populations noted on earlier records for that area and identify others by their own observations. Their field reports are turned over to data handlers who keyboard threatened or endangered species and communities into a computer, ranking each according to the extent of its peril.

The white lady's slipper, *Cypripedium candidum*, for example, is ranked in the Georgia Heritage Program as a G3S1. Based on a numerical ranking of 1 through 5, this means that it is not in serious danger globally (G3) but is very rare in that state (S1). The plants ranked G1S1 are extremely rare worldwide and in the state where they are found, such as the leafy prairie clover, *Dalea foliosa*, in Illinois. Information from each state is fed into a main computer at Conservancy headquarters in Arlington, Virginia, across the Potomac River from Washington, D. C. By cross-referencing them on a grid of information, the current status of any of more than 50,000 plants and animals can be checked within seconds.

"It's the most complete data base on biota in the world," said Robert Jenkins, architect of the inventory system.

Such an inventory is under way in New Jersey, a lush temperate region where flora and fauna are disappearing under residential and industrial development. "We find rare species regularly—orchids and sedges normally found on prairies," said David Snyder, a thirtyish botanist with an auburn beard and an earnest brow.

We sought a vinelike plant of the pea family called *Desmodium pauciflorum*, ranked in New Jersey as a G5SH. This means that it is in no danger globally (G5), and in this state (S) it has been reported historically (H) but not seen in recent years.

Normally a midwestern and southern plant, *D. pauciflorum* was last seen in New Jersey in 1917 by Kenneth Mackenzie, a lawyer and plant collector. His descriptions led us to a ten-acre forest remnant, surrounded by houses and the faint hum of traffic. Ninety minutes of searching failed to turn up one example. If clues to other locations also proved fruitless, it eventually would be listed on Heritage Program records as "extirpated" in New Jersey.

Why the interest in saving plants that are commonly found elsewhere? "When a species is out of its normal range, it is at the edge of its tolerance of its environment and probably became separated from others of its own kind," David explained. "That may make it evolve a little differently, and those variations may become useful.

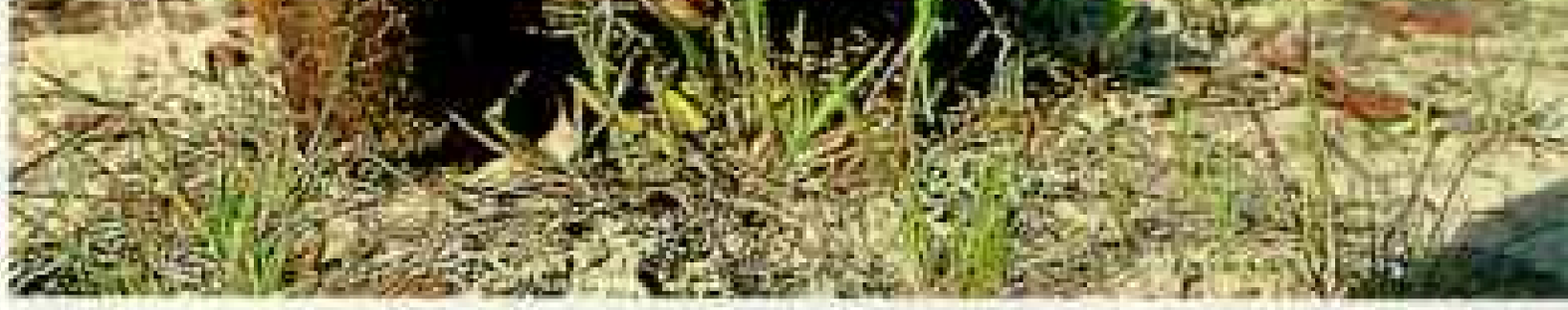
CORPORATE WEALTH and ecological concern dovetailed in the transaction that is helping preserve acreage in Florida's Big Bend region on the Gulf coast. George Willson, at left, the Conservancy's director of Florida land acquisitions, meets with Harry Van Loock, lands and timber manager for Procter & Gamble Cellulose, among the largest contributors to the acquisition. The Conservancy has helped preserve about 76,000 acres in the area, which will become state-managed land, forming a link between two national wildlife refuges.

A strain of wild wheat at the limit of its range in Israel, for example, was found to be highly drought resistant."

Our second quarry was in the Pine Barrens, an hour's drive south, a colony of southern yellow orchids that the Heritage Program has been monitoring. "Forget where you saw these," David told me as we pushed through brush to a little meadow where gold blossoms gleamed at the end of long stalks. "A lot of plant collectors would love to find them."

Somebody already had, and marked a route with orange survey tape. Jaw set, David ripped the tape from the brush. "Collectors decimated a population of snowy orchids from a bog not far away," he said angrily.

BUSINESS minds take over from the biologists when protection becomes necessary. The Nature Conservancy completes an average of one land deal each day in the United States. The biggest was 220,000 acres of desert in New Mexico, bought from the Campbell Family Foundation and now Sevilleta National Wildlife Refuge. Such land is paid for by fund-raising in that state. Since campaigns take months and deals often require haste, ready cash for a large acquisition is available from the TNC Land Preservation Fund, maintained at 85 million dollars. Regional offices can complete land deals as high as $100,000 without a go-ahead from headquarters. Salaries and other overhead come from endowment income and Conservancy memberships, currently more than 400,000 nationwide. Staff workers are consistently bright, well educated, and, among the nonbiologists, more articulate about balance sheets than biota. The business-like approach to environmental matters can strike an air of incongruity, as though one were



ARTFULLY POISED on a branch in Florida's Wakulla Springs, a limpkin (facing page) eyes its surroundings for food. The bird, whose survival in Florida is threatened, feeds almost exclusively on the apple snail, which lays its eggs on exposed vegetation. Saving the freshwater springs, part of Big Bend, will promote the welfare of both prey and predator.

Another link in the food chain at Wakulla is strengthened by the globally threatened gopher tortoise. Burrows created by the tortoise to escape heat and cold are used by mice, snakes, owls, rabbits, and hundreds of other animal species. The Conservancy has played a major role in preserving more than 170,000 acres of land along Florida's streams and rivers.

watching Wall Street make preparations for the second Earth Day.

As Oregon director, Russ Hoeflich keeps track of perhaps 250 possible acquisitions at any given time. He also raises funds, seeks to expand state memberships (10,000 in 1988), and supervises 14 people. This dynamo is a decade out of college, a year out of New York, and still wears chinos and loafers in a land of jeans and cowboy boots. To check on some potential projects, we drove the arid canyon-and-river country of eastern Oregon to the cow-conscious town of Enterprise. Joining forces with field representative Geoff Pampush, we picked up Ray Hockett, a crusty rancher in his 70s. Ray owns some 2,000 acres of prime grassland around a water hole called Downey Lake, and TNC wanted a couple hundred acres of the shoreline. The shorebird called greater yellowlegs, which nests nowhere else in Oregon, hatches its young here, as do other shorebirds and waterfowl.

Ray wants water for his cattle, and behind his slow voice and half-lidded eyes lurks a mind as precise as a surveyor's transit. At the lake an offhand comment by Geoff on the proposed TNC property line turned Ray's amiable drawl into a sharp rebuke: "Not behind those rocks, in front of them! We're just talkin' about land close to the lake!" After five years of negotiations he continued to balk at the sale.

A second potential acquisition seemed too easy. Bonnie and Alan Bahn, a young couple with two children, own a small ranch with a rich marsh along its creek. "We probably can't stop housing development from ruining it eventually, so we want to work with you to turn the place into a preserve," declared Alan, a lean outdoorsman who sat in a straight-backed chair as if for the first time. His job in town is their main income.

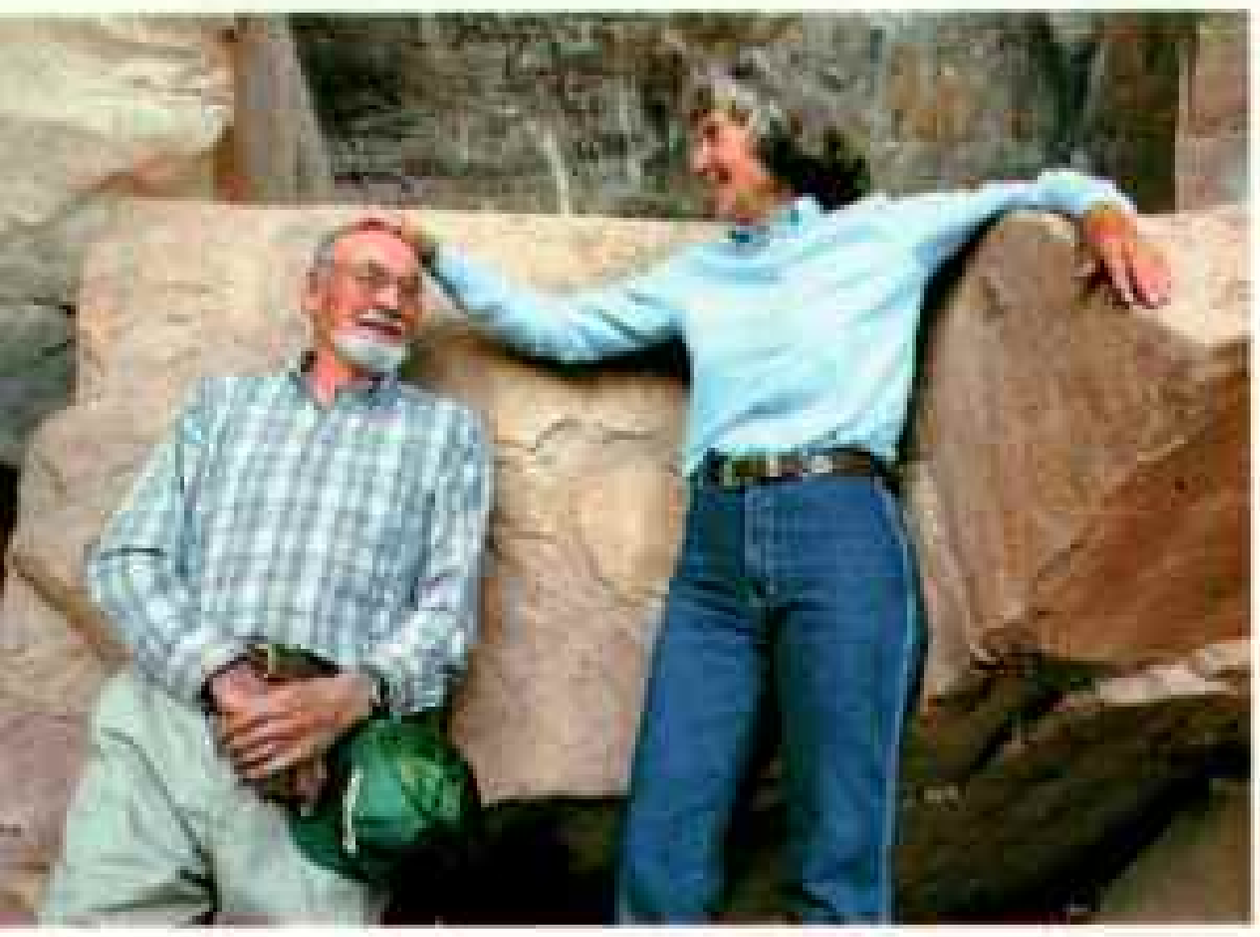
"I don't care about money, I just want a roof over our heads," said Bonnie, who nurses orphaned and injured owls, hawks, and raccoons.

"This place is your equity," Russ gently demurred. "You should retain something for your kids' education."

There are several options open to the idealistic couple, he explained. They could retain ownership in the house and donate the land, taking income tax deductions over the next six years. Or they could keep house and land and grant a conservation easement, which could lower their property taxes and assure protection of the endangered plant community.

"Taking advantage of generous people won't help our reputation," Russ added.

Creative land deals are at the core of Conservancy work, and protection has come in a number of imaginative ways. On Martha's Vineyard, the trendy vacation island off the Massachusetts coast, TNC bought a small-plane airport to preserve a remnant of pure eastern prairie, then leased the airport's operation. On Shelter Island at the end of Long Island, in New York, it sought protection



"DEVELOPMENT PRESSURES are enormous," says Keith Lewis (top) of Rhode Island's popular Block Island. Spurning wealth, the merchant seaman sold 43 acres to the Conservancy at a rock-bottom price. Robert and Mary Kittredge donated 50 acres to prevent encroachment into an Arizona canyon, the site of Indian pictographs, in return for the right to use the property for life.

for ospreys nesting on the 2,039 acres of a hunting club. The real estate company that owned the club would not sell it alone. So TNC bought all the company's holdings—nine brownstones in Manhattan, a warehouse in Miami, oil and gas leases in three states—for 10.65 million dollars. It then sold all but the former club, where active osprey nests have since doubled. In Mississippi it bought controlling interest in a lumber company to save a large tract of bottomland hardwoods, a biotic community rapidly disappearing.

A few deals have been so creative as to invite criticism. When the owner of an Atlantic coast property said he would sell only to a developer, TNC bought it in the name of a dummy company and turned it into a preserve. Cries of deviousness came from local residents who had hoped for the financial boost of a population influx.

The most heated criticism is that TNC sometimes fosters development. In Vermont 731 acres, deemed of no significant ecological value, were sold with the donor's consent to a developer. The money was then used to buy ecologically significant land. Public outcry subsided with the explanation that local zoning would prevent high-density housing on the land originally donated.

On the Virginia coast the Conservancy plans to resell 12 parcels totaling 6,000 acres—an act seen by one angry columnist as development. Greg Low, TNC director for the project, says land-use

ODD SHAPES and unlikely locations of imperiled habitat matter little to preservationists. What may be weed patches to train travelers are actually remnants of native prairie. The Conservancy is protecting and managing six strips of grassland along a 70-mile stretch of track in southwest Michigan, after leasing them from the National Rail Passenger Corporation (Amtrak).

DENUDED SLOPES reflect natural erosion aggravated by the foraging of feral sheep and pigs on California's Santa Cruz Island. The Conservancy owns 90 percent of the 62,000-acre island, its largest holding. The habitat destruction threatened several unique populations, including the Santa Cruz Island scrub jay, which has grown to be larger than its mainland cousins.

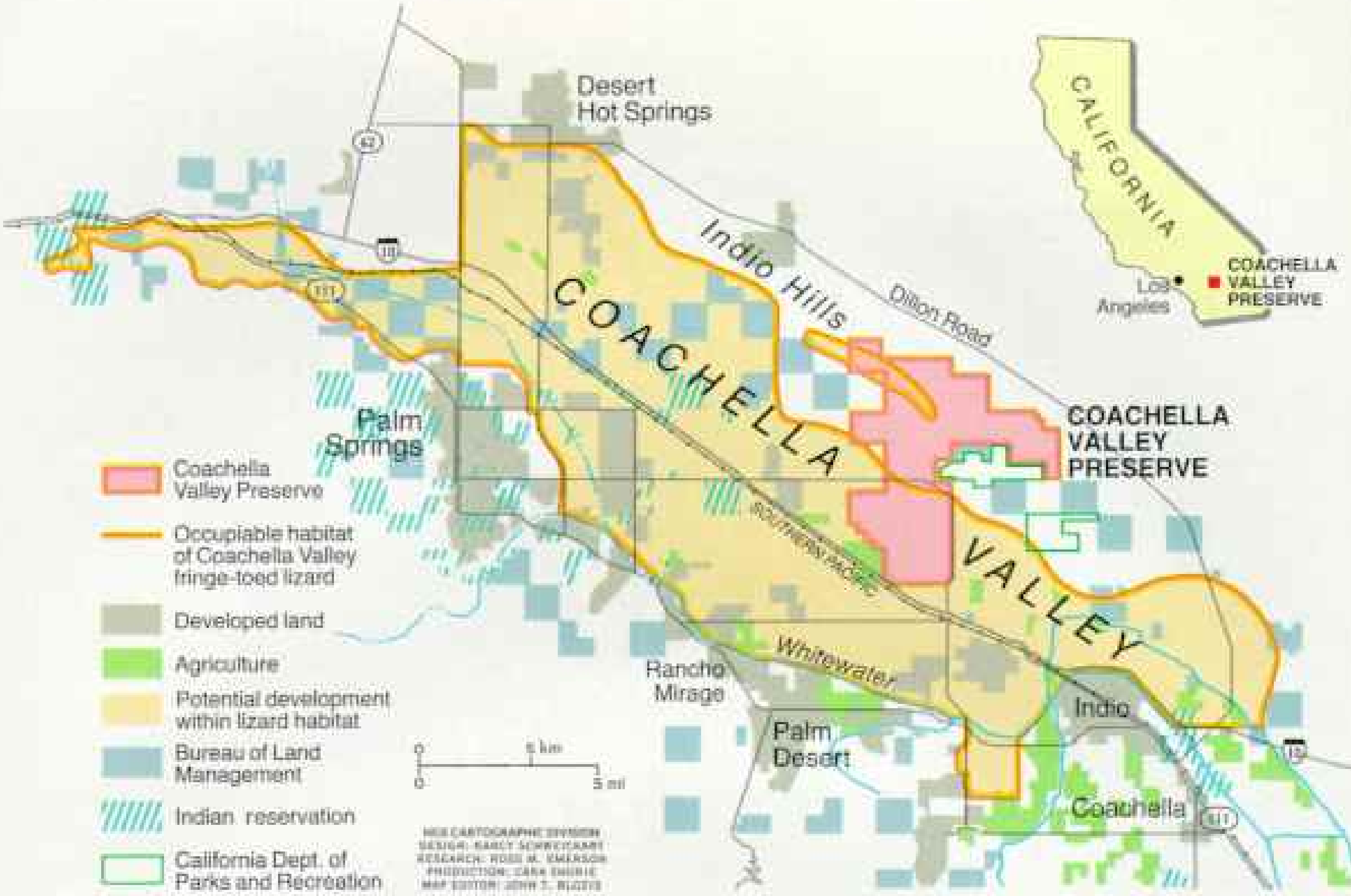
In the early 1980s the Conservancy eradicated 30,000 sheep after other efforts to remove them failed. The organization explained that the cost of moving the animals would have been prohibitive. The carrion from the fallen sheep provided abundant food for the feral pig population, which rose dramatically. Researcher David Sterner makes a difficult catch of a young pig for a study to help determine the optimum population level.

The project is beginning to pay off with the return of plant growth, including the now flourishing silver deerweed, once on the brink of extinction.

restrictions added to the plots would save ocean bays and inlets from pollution. "We're trying to demonstrate that human activity can take place without harming the environment," he stressed.

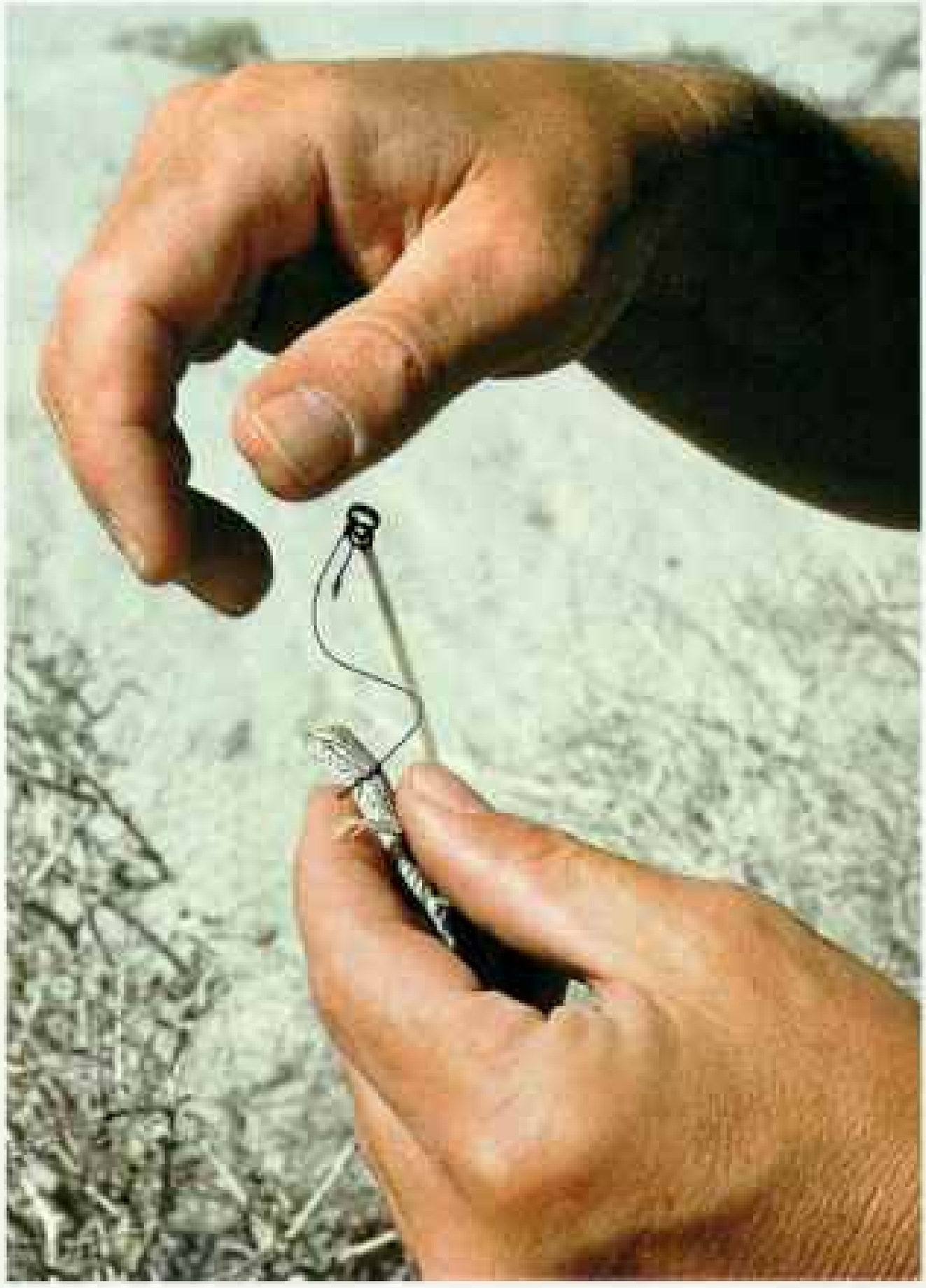
BUYING, SELLING, and managing land are a far cry from the early days of the Conservancy and the organizations that preceded it. At his sylvan retreat near Hartford, Connecticut, Dick Goodwin, a former TNC president, recalled the slow evolution of the organization. "We weren't very picky in the old days," he said. "Any nice, undisturbed piece of land would do. I had the idea that this one would be a place where scientists could conduct long-term ecological research." Before us a small meadow dappled with butterflies stretched to a woods that the Goodwins donated as one of the Conservancy's first preserves, now 500-acre Burnham Brook.

White-bearded, slender, professorial . . . one could imagine the retired botany professor of Connecticut College in New London contentedly netting insects, glassing birds. The profile was probably true for the majority of the early conservationists who in 1917 at the University of Illinois formed a special committee of the Ecological Society of America, which urged the preservation of natural areas. In 1946 this committee split off to form a group called the Ecologist's Union. "It was a real penny-ante operation in those days, with a handful of members kicking in two dollars in annual dues, some giving as much as ten dollars," explained Goodwin. "But in the 1940s the union was joined by Dick Pough, a



The lizard that vanquished a valley

THE MARCH OF DEVELOPMENT across California's Coachella Valley has been slowed in the tracks of the fringe-toed lizard, thanks to a hard-won compromise. The tiny creature requires a habitat of dunes with sand of a certain consistency. Citing the Endangered Species Act, the U. S. Fish and Wildlife Service sought to curtail new growth on the desert range of the lizard and other species. A home builder responded by threatening to sue, resulting in a stalemate. Aided by a 2.5-million-dollar land-acquisition grant from the Richard King Mellon Foundation, the Conservancy drew numerous interests together for negotiations. The result: the preservation of 13,000 acres, where a hatchling (right) is snared for a population count.



fellow with lots of connections and a 'get off your butts' attitude."

When I met him at his summer home on the island of Martha's Vineyard, Pough seemed more entrepreneur than ecologist, the kind of mellow-voiced, chatty man who could mix easily with royalty and wealth. An engineer by training, he acquired a deep love and broad knowledge of the environment, and a reputation as an organizer.

"I had returned from London after a meeting with my friend, ornithologist Sir Peter Scott," he recalled, long legs crossed, "and I was enthusiastic about the preserves of the British government's Nature Conservancy. I argued that we adopt the same name but stay private and buy preserves with private funds."

In 1951 the Ecologist's Union became the Nature Conservancy. It made its first purchase two years later—60 acres in picturesque Mianus Gorge, some 30 miles north of New York City. For some early acquisitions, members mortgaged their own homes to come up with funds. Then Pough lunched with Mrs. DeWitt Wallace, co-owner of the *Reader's Digest*, and received $100,000. Since then contributions have reached the 85-million-dollar total now in the revolving Land Preservation Fund. Pough also managed the bequest of Minnesota mining heiress Katharine Ordway, a personal friend and lover of the environment. "Much of that 55 million dollars went for TNC land," he said.

MAN-MADE HABITAT near Thousand Palms, California, Tri-Palm Estates plans eventually to expand from 1,500 to 2,400 mobile homes. Located west of the Coachella Valley Preserve, Tri-Palm will pay a $600-per-acre mitigation fee now imposed on all new development in the valley to help defray the cost of the preserve.

Many view the Coachella agreement as a model of compromise that preserved a pristine habitat as it increased the value of adjacent land, satisfying both developers and environmentalists.

With the funding of the Conservancy in hand, Pat Noonan set its personality during his presidency from 1973 to 1980. A mid-fortyish man on the run, he has the piercing eyes of a businessman set in the cherubic face of an altruist, both of which describe his attitude toward conservation. "A lot of us came out of business schools in the sixties when the environmental movement was taking hold, and we loved the outdoors," he told me over breakfast in Washington, D. C. "Corporations and environmentalists were butting heads, but we knew the free-enterprise system was a fantastic motivator. So the Conservancy decided to reach out to corporate America. No other environmental group was doing it."

The first big land donation in 1973 set a record for corporate gifts. Some 50,000 acres of the Great Dismal Swamp of Virginia and North Carolina, given by Union Camp Corporation, was valued at 12.6 million dollars. When a more traditional environmentalist suggested that a gift that size from big business was tainted money, the quick-witted Noonan countered with the line: "It may be tainted, but 'tain't enough."

Criticism of TNC's apolitical, nonconfrontational style persists, although success has dimmed it somewhat. "We can't help but wish they'd get their hands dirty once in a while," an officer in another environmental group told me, "even though they have led the way in preserving biotic diversity."

For instance, he added, TNC once publicly praised the generosity of an oil company that donated a valuable piece of California property. Staff of another organization pointed out to them that the

PLACID WATERS fed by thermal springs mist the air above Borax Lake in southeast Oregon, where Conservancy workers strive to save a zoological rarity from extinction. Only here is found the Borax Lake chub (facing page), a fish intriguing to scientists. Over the ages as its habitat shrank to a ten-acre lake, the fish has grown smaller. Now about the size of a minnow, the chub also has adapted to temperatures ranging from 62 to 95 degrees.

STANDING FAST on her ancestral land, Pat Frazier (left) has been a grudging partner in Conservancy efforts, puzzled by interest in the Borax Lake chub. She and her cousin own 320 acres on which the lake lies. They are descendants of settlers who arrived on the Oregon Trail. Her grandfather, a Danish immigrant named Christian Ollgard, invented a process for refining borax from deposits around the lake.

One of her forebears posed beside a mule team (facing page) used to haul the product to a railhead in Nevada. The trade name Twenty Mule Team Borax was also used by a company located in Death Valley, California. Frazier feels that her property does have a value beyond its beauty, chiefly the potential for geothermal energy production. She granted the Conservancy a lease to manage the lake after five years of negotiating, an agreement she now disputes. She once greeted a Conservancy worker at her door with a shotgun. The organization hopes eventually to buy the land. Meanwhile it continues its program of managing the lake's water level and looking for other species. The chub may help reveal how organisms adjust to radical temperature changes.

SURVEYING A GRAND DOMAIN, a prairie falcon watches over Snake River Birds of Prey Area in Idaho. Administered by the Bureau of Land Management, the area harbors perhaps the world's densest nesting population of raptors.

As farming supplanted cattle grazing on adjacent flatlands, prey species such as jackrabbits and ground squirrels were routed. By acquiring unplowed ranch land, the Conservancy is providing a prey base for such species as the golden eagle (facing page, bottom). But the imperiled peregrine falcon (shown here at a research station) feeds mostly on other birds, and has not been seen in the area for ten years.

land was relinquished only after years of protest by others against the oil company's original plans for developing it.

"Noonan set our negotiating style," said vice president Dave Morine, "the attitude that no one is ever completely wrong. We don't believe anyone purposely goes out to destroy the land. You just have to understand their priorities and appeal to them."

Communing with corporations may be the Conservancy's forte, but their coffers have also been swelled by individual acts of generosity. Legendary is the late Willie Brown, a Florida bachelor of modest means who donated rolling woodlands and marsh along the St. Johns River to keep it natural. As part of the bargain he lived on the property, valued at more than a million dollars, until his death.

Keith Lewis is a sixth-generation resident of Block Island, the offshore chunk of Rhode Island invaded each summer by thousands of tourists. A merchant seaman with a nautical beard, he has the all-business build of a tugboat. The shrinking open space on his beloved four-by-six mile island turned him toward the Conservancy. Land that would have made him a millionaire he sold at a bargain price in a deal that merely paid off his mortgage and left him a chunk of land to live on. "Fourteen percent of the island is protected now," he said. "I'd like to see us get to 25 percent."

Open space was not the only benefit. Hard-pressed upland sandpipers and grasshopper sparrows nest in the saved habitat, and barn owls burrow in the cliff faces. In one meadow I joined biologist Tim Traver in a catch-and-release inventory of a butterfly now

under reprieve, thanks to Lewis. It was the stuff of cartoon strips, bounding with net held aloft in pursuit of the regal fritillary, and great fun in the name of science.

INCH-THICK boards fence in Glenn Plumb's charges on the Samuel H. Ordway, Jr., Memorial Prairie in South Dakota, where grasslands stretch as far as the eye can see. The young preserve manager in a slouch Western hat herds bison on the 7,800 acres. "To maintain prairie plant diversity, we need both controlled fire and grazing," he told me as we toured sturdy corrals and catch pens. "The bison provide the grazing, and the sale of extra animals brings in $25,000 a year to help with expenses.

"Nothing could be more ecologically stable than a healthy prairie," Plumb said as we walked into a waving sea of big bluestem, switchgrass, and Indian grass.

Stewardship of the lands it acquires is an increasing financial burden on the Conservancy, and more and more preserves are trying to pay their own way. In western Montana the operation of a dude ranch covers expenses for 18,000-acre Pine Butte Swamp Preserve, where the real guests are grizzly bears.

In centuries past grizzlies climbed the eastern front of the Continental Divide in fall to winter over in dens dug in the hard-packed deep snow. Come spring they wandered down to the plains to feed on the carrion of winter's victims, on cow parsnip and angelica. Unfortunately for the grizzly most flatlands are now crowded with towns and ranches whose residents harbor considerable bias against *Ursus arctos horribilis*. Pine Butte Swamp Preserve is a bear smorgasbord of grasses, forbs, and berries, and some locals have accused TNC of running a bear farm that puts them and their livestock at risk, although no bear attacks have been reported.

The man who characterized Montana as the "Big Sky" country with his novel of the same name considers grizzlies good neighbors. "We never see them," said 87-year-old A. B. "Bud" Guthrie, who lives with his wife, Carol, at the edge of the fen. "Any contact ranchers have with them is mostly through their own carelessness in disposing of cattle losses or old molasses cattle feed. Grizzlies are part of our heritage, and we should make room for them."

Legendary fear of another fanged creature might have raised alarm on the East Coast. In North Carolina the Conservancy encouraged the donation by Prudential Insurance Company of 118,000 acres between the Alligator River and inland waters of the coast, then passed the gift on to the U. S. Fish and Wildlife Service. On spongy wetlands called pocosin, covered by cypress, sweet and black gum, dense brush, and declining Atlantic white cedar, Fish and Wildlife is reintroducing the endangered red wolf.

"It's the first attempt at reintroducing a predator that had ceased to exist in the wild," said refuge director John Taylor, "and we're being watched closely by people who would like to do the same with the black-footed ferret and Florida panther."

Watching as well are locals whose knowledge of wolves came primarily from "Little Red Riding Hood." "We had public meetings before the wolves arrived," said Taylor, "explaining that they'd be lucky if they ever saw one of the shy creatures. There were objections at first, but now I think there's a lot of pride in bringing back an animal that once ranged all over the Southeast."

INCREASINGLY, making room for endangered species cuts into expensive real estate—and calls for even more complex solutions. "The days are gone when we can ride in on a white horse, buy a piece of land, and beat our breasts about how we saved it," said David Harrison, chairman of the TNC board. "More and more we have to sit down with a group of different interests and work these things out so everybody wins—developers, environmentalists, and government."

A solution at Palm Springs, California, is held up as the model compromise. Biologist Cameron Barrows took me for a walk on 30-foot-high sand dunes in Coachella Valley, home of sunbaked luxury communities. Suddenly a small lizard flashed across a dune and disappeared into the sand. "It's probably swimming toward that patch of arrowweed," said Barrows.

Sand diving is the nine-inch fringe-toed lizard's defense against predators and the midday heat. Its needs are precise—grains fine enough to dive into but not so fine as to clog its tiny nostrils. The toe fringe helps it speed over the surface. A spacious windswept area is needed to create such conditions. When a host of satellite towns began expanding beyond Palm Springs into the valley, the lizard was threatened with a dive into extinction.

U. S. Fish and Wildlife attempted to shut down development under the Endangered Species Act, a move urged by environmentalists. Sunrise Development Company, with a plan for luxury homes, wanted to fight the shutdown in the courts. The county government sided with Sunrise, foreseeing more taxes from rich residents than from lizards. The battle lines were drawn.

"The environmental community felt a compromise was possible, but we had no experience in fund-raising or negotiating," said herpetologist Allan Muth. "So we called in the Nature Conservancy. They got us together, presented some options, and in the end everyone was happier."

The result: 13,000 acres in a preserve that includes more than 5,000 acres of lizard habitat. Developers and county supervisors found the resulting open space made property for housing even more desirable and valuable. State and federal governments shed an expense when TNC created a trust to manage the land. Now two additional reserves have been approved and another 2,500 acres set aside where the lizards can live.

Local lawyer Paul Selzer, central in negotiations, said of the Coachella compromise: "It was impressive . . . industry, government, conservationists all coming together and saying let's all pay a few bucks and get it done. Personally it was one of the most rewarding things I've ever been involved in."

UNLIKELY LOCATIONS for wildlife, freeway signs are nevertheless proving successful in Idaho's effort to accommodate the American kestrel, once called the sparrow hawk. Craig Groves, state coordinator of the Conservancy's Heritage Program, and Bureau of Land Management raptor biologist Karen Steenhof check a nesting box next to Interstate 84 east of Boise.

Among the few kinds of falcons that will use a man-made house, kestrels have occupied nearly a quarter of the pine and cedar boxes constructed by Boy Scouts, Audubon Society members, and other volunteers. So far 82 boxes have gone up, 32 of them along I-84, the remainder in the Birds of Prey area and other rural locations. The kestrels, which feed on insects and small rodents, have occupied the highway houses readily, perhaps because of the availability of perching places, such as trees and telephone poles.

THE LONG arm of TNC reaches beyond the contiguous United States, beyond national boundaries to the south, and westward across the Pacific. Hawaii is a showcase of endemic species. "This is the most isolated significant landmass on the planet," state director Alan Holt told me at Conservancy offices in Honolulu. "The nearest coast is California, 2,500 miles away, so anything that migrated here evolved with little outside influence."

The differences have already paid dividends. As we walked on the island of Maui, he pointed to a bush of wild Hawaiian cotton

that has removed one need for pesticides. "This cotton doesn't exude the nectar that aphids and scale love on commercial cotton," he explained. "Crossing the two eliminates the nectar and therefore the insects."

The bank of Hawaiian specialization is being raided by other species introduced by man. Ornamental plants are crowding out native species. The mongoose was introduced to kill shipborne rats, but the mongoose turned to birds. Some 70 species of birds have become extinct in Hawaii, and of the 36 remaining, 33 are rare and endangered. Of the total 6,000 plant and animal species that the Conservancy feels need protection throughout the U. S., a thousand face a tragic aloha in the Aloha State. To prevent the loss, TNC has undertaken a ten-million-dollar "Islands of Life" fund-raising campaign to acquire and protect land.

With Alan I helicoptered over Maui's leeward side, stripped bare by feral goats and pigs. Gullies ribbed the mountainsides, and red soil bled into the sea. On the windward side the Conservancy has acquired a conservation easement to hunt the unwanted animals and remove them from 5,230 acres of native forest and scrubland on the Haleakala cattle ranch.

"We knew feral animals were affecting the water runoff by destroying vegetation," said Peter Baldwin, the ranch president. "With the easement, we preserve a watershed and the Conservancy gains an ecosystem."

In Central America, chain saws are eating away tropical forests that harbor a rich biological network. "A dollar spent here will buy ten times more species preservation than a dollar spent in the temperate zones," I was told by David Clark, a plant ecologist in Costa Rica. "Also, many bird species seen in the U. S. winter in the tropics, making it necessary to save habitat in both places."

Recognition of tropical needs resulted in creation of the Nature Conservancy International Program in the late 1970s, now the Latin American Division. To avoid the appearance of "gringo" intrusion, the new branch became a silent partner with local conservation groups, lending financial support and training in the methods of TNC negotiation and acquisition.

In Venezuela it inspired formation of a group called BIOMA (as in biomass, or biota) and trained its first executive director, Aldemaro Romero, in Washington, D. C., for a year. In Panama it helped formulate ANCON (Asociación Nacional para la Conservación de la Naturaleza), and in Costa Rica it helped a fledgling National Parks Foundation burgeon into an effective force for species protection.

In a few short years the program sparked protection of more than

three million acres and creation of conservation data centers in several countries. But it also sparked a "palace revolt" in 1987 over the amount of autonomy the international program should have and its methods of operation. Thirty-four staff members resigned to form a new organization. Within a year, however, the volleys of harsh words had subsided into mutual compliments, even cooperation between TNC and the new Conservation International.

The Latin American Division uses creative financing as a tool. A growing national debt had cut into Costa Rica's ability to protect land. Swapping debt for nature, the Conservancy has helped swell conservation coffers while curbing the outflow of foreign currency from Costa Rica. Using Conservancy money, the National Parks Foundation bought a portion of the nation's debt from a U. S. bank, paying in dollars after the debt was discounted to only 17 cents on the dollar. Costa Rica then paid off the Parks Foundation with bonds in the local currency, colones, with the agreement that the money would be used on conservation projects. More bonds were issued this year when another American bank donated $254,000 of Costa Rican debt to the Conservancy.

Conservancy money did not buy 1.5 million acres of *llanos*, or savanna, in Venezuela, but it played a part in its future. A BIOMA suggestion of using satellite imagery to survey the area so impressed Venezuelan officials that the TNC-backed group was asked to plan a huge new park.

An appeal to practicality yielded results in Panama, which has lost 60 percent of its forest cover since the turn of the century. Millions of gallons of fresh water needed daily to operate the canal locks seep toward the waterway from forested uplands, also fecund with wild species. Denuding those uplands—a growing threat—would destroy habitat and eventually silt in the canal, bulwark of the Panamanian economy. Working through its local creation, ANCON, the Conservancy led the way in agreements and funding that protect the watershed.

JEKYLL-AND-HYDE transformation protects the caterpillar of the sphinx moth (above), also called the hawk moth. To frighten predators, it inflates its thorax to mimic a snake (right); its bogus eyes even have spots resembling reflected light. Conservancy funding helped acquire a strip of Costa Rican forest, stretching from the lowlands to the mountains. Harboring earth's most diverse array of life, the tropics may contain undiscovered species that, unless habitat is saved, could vanish, never having been known by man.

PRACTICALITY is not the only reason for preventing extinctions, according to Larry Morse, who manages the Conservancy's national data center at the Virginia headquarters. "You can also argue that we have no right to wipe out species that have existed for millions of years, or you could say that with every species lost in the chain of life, we humans are that much closer to extinction.

"Practicality just happens to be the argument that most people can accept."

Perhaps the point was best made by botanist Peter Lesica to a rancher in Montana on whose land grew a threatened prairie carnation. The Conservancy wanted to protect it with a conservation easement that would restrict some use of the flower's surroundings but allow the rancher a tax deduction.

"This flower you want to save," asked the rancher testily, "is it good for anything?"

"We don't know yet. But if you see a bolt on the ground, do you throw it away?"

"Course not. I might need it some day."

"We feel the same way," said the botanist, "about the prairie carnation." □

MIGRATING TO THEIR WINTER RANGE, CARIBOU OF THE WESTERN ARCTIC HERD CROSS THE KOBUK RIVER IN NORTHWEST ALASKA

MAJESTIC WANDERERS

CARIBOU

Photographs by MICHIO HOSHINO

Drawn by the slow, inevitable pull of instinct, one of the world's great wildlife migrations occurs each spring in the far north. Leaving their winter homes south of the Brooks Range, more than 400,000 caribou in northern Alaska and the Yukon head north to the Arctic coast. First in a trickle, then in a flood, the herds follow age-old migration routes across rivers and around mountains to calving grounds on the coastal plain. There they give birth on the flowering tundra and fatten on plants that burst forth in the brief Arctic summer. They face the perils of predation and endure hellish clouds of insects—playing their part, year after year, in a wildlife pageant rooted to this raw, fragile land.

BUNCHBERRY (DWARF DOGWOOD) IN BLOOM

Coaxed by its mother, a newborn calf wobbles to its feet in Alaska's Arctic National Wildlife Refuge (ANWR), perennial calving grounds for the 170,000 caribou of the Porcupine herd. Newborn calves are easy prey for wolves, grizzly bears, and other predators, which may partly explain why caribou prefer to give birth on the coastal plain, where hunters can be spotted from a distance. Within minutes a calf can stand. After a week it keeps up with its mother, and at three weeks it can outrun a grizzly.

PASQUE FLOWER BRIGHTENS THE TUNDRA.

Headed for rendezvous with cows and calves, bull caribou follow the Kongakut River down from the high country toward ANWR's coastal plain. Bands of the reunited herd

often return to these foothills of the Brooks Range to rebuild their strength after calving, then head north again as the nutrient-rich tundra ripens and mosquitoes begin to hatch.

As the precious days of summer grow shorter and cooler, caribou of the Denali herd, south of the Brooks Range, graze the tundra with a new urgency, building the body fat they will need to survive the dark, bitter months of winter. By September males have begun to unsheathe their newly grown, velvet-covered antlers—all-important weapons in the autumn rutting season.

Stampeded by bloodthirsty insects, a band of the Porcupine herd in ANWR flees the billions of mosquitoes and biting flies that feast on the animals each summer. The caribou's

defense is to congregate and keep moving, burning precious energy, or to hug the coast, where ocean winds sometimes ground the weak-flying mosquitoes.

* * *

OIL IN THE WILDERNESS

An Arctic Dilemma

By DOUGLAS B. LEE

Photographs by JAMES P. BLAIR

BOTH NATIONAL GEOGRAPHIC STAFF

SOMEWHERE north of Dawson and Fairbanks, east of Prudhoe Bay and west of the Mackenzie River, you will find neither an Alaska nor a Yukon Territory, no Canada or United States. Instead you enter a land of mountains and broad, lake-filled plains, where caribou have worn trails in rock and geese have traced paths in the sky over millennia of rhythmic wandering; where ice holds the sea and frost the land until a brief, glorious burst of flowering summer; and where men have hunted creatures hoofed and finned and feathered for longer than science can tell. It is a roadless land, a part of the North little touched by the 20th century, or the 19th, or the first. But it is a place where, as sure as daybreak, the South is about to arrive.

For beneath its tundra and a thousand feet of permafrost lie strata that may hold enough oil to transform vast tracts of wilderness and the adjoining sea into one of the largest energy-producing complexes in North America.

During five months of Arctic travels in Canada and Alaska I explored this region, camping, boating, and flying with native people, scientists, oilmen, and defenders of wilderness. The palette of opinion is vivid and multihued, and decisions on preservation and development will permanently imprint this coast of two countries.

"As far as I can tell," says Tim Mahoney of the Sierra Club, "we're standing in the world's greatest Arctic ecosystem. We say, if they can drill here, where can't they drill?"

"Here" is 200 miles north of the Arctic

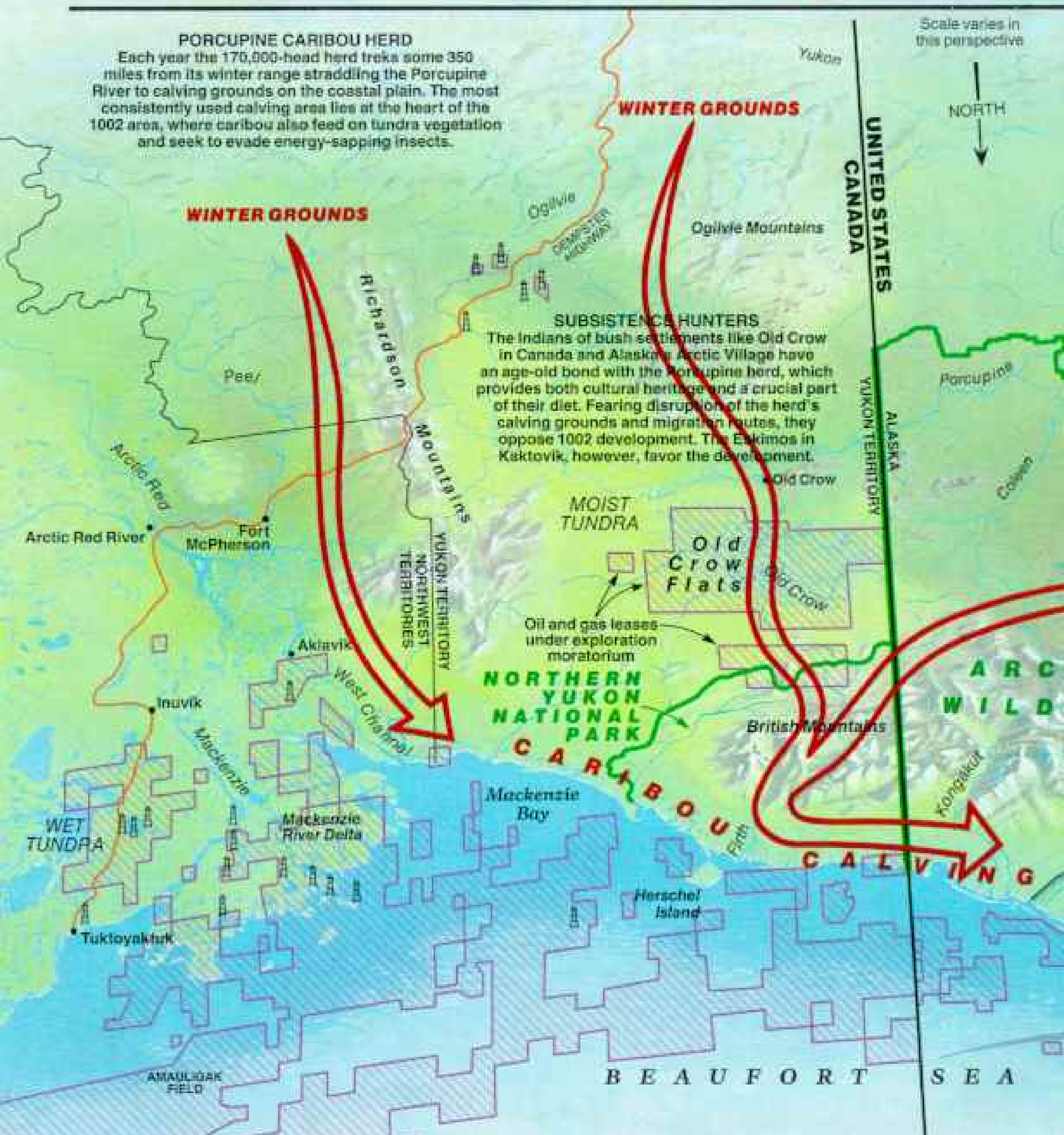
At a point of no return, Congress must decide whether to unlock Alaska's Arctic National Wildlife Refuge to oil companies working just offshore—or preserve it intact for all to use, including the Gwichin Indians (above), who have lived on the refuge's migrating caribou for generations.

EARTH '88

"We clearly have an obligation to safeguard the biosphere. It is our home, which we share with all other known life, each dependent upon the others. It supplies our sustenance and stores the legacies of evolution and human works. It provides opportunities for future generations . . . to enjoy the wonder, beauty, and variety of nature."

—Russell W. Peterson,
President Emeritus, National Audubon Society

PORCUPINE CARIBOU HERD
Each year the 170,000-head herd treks some 350 miles from its winter range straddling the Porcupine River to calving grounds on the coastal plain. The most consistently used calving area lies at the heart of the 1002 area, where caribou also feed on tundra vegetation and seek to evade energy-sapping insects.



Two countries–one ecosystem

Often compared to the Serengeti because of its vast concentrations of wildlife, the region traversed by the Porcupine caribou herd ranks as one of the most significant unspoiled Arctic ecosystems in the world. It's also the most promising oil prospect in North America, say those who have drilled offshore and at nearby Prudhoe Bay.

Declaring the area a national treasure, the U. S. Congress expanded the Arctic National Wildlife Refuge (ANWR) to 19 million acres in 1980. Setting aside 1.5 million acres of ANWR's coastal plain (designated the "1002 lands"), it directed the Department of the Interior to weigh that area's oil potential against its value as wilderness and wildlife habitat. In a controversial report, Interior recently recommended leasing the entire "ten-o-two" for exploration. Canada declared much of its side of the coastal plain off-limits to drilling in 1984.

BBN CARTOGRAPHIC DIVISION. DESIGN: BOB PRATT; RESEARCH: ANN HARRY; PRODUCTION: PHOEBE MURRAY, GEORGE MCCALLUM; MAP EDITOR: GUS PLATIS. OIL AND GAS LEASE INFORMATION PROVIDED BY ALASKA MAP SERVICE, INC., ANCHORAGE, ALASKA; THE MAPMAKERS, PALMER, ALASKA; ESSO RESOURCES CANADA LTD. AND OIL AND GAS LANDS ADMINISTRATION, OTTAWA, ONTARIO. PRINTING BY BOB WOOD

Fairbanks
Tanana
TRANS-ALASKA PIPELINE
Yukon
Black
Fort Yukon
Chandalar
Sheenjek
WINTER GROUNDS
Arctic Village
SPRUCE/ HARDWOOD
Brooks Range
Dalton Highway
Sagavanirktok
PRUDHOE'S CARIBOU
Unlike the Porcupine herd, the central Arctic herd is small (18,000) and nonmigratory, with room to roam over the hundred-mile-wide coastal plain south of Prudhoe Bay. Despite oil-related development, its numbers have tripled during the past 15 years, although the animals shun manmade structures during calving.
Aichilik
Jago
Hulahula
Road and pipeline design used in environmental study for 1002 report
GROUNDS
1002
Canning
Kaktovik
Kaktovik Inupiat Corporation lands
Barter Is.
BP/CHEVRON EXPLORATORY WELL SITE
PRUDHOE BAY FIELD
ENDICOTT FIELD
LISBURNE FIELD
Prudhoe Bay
Deadhorse
KUPARUK FIELD
MILNE POINT FIELD
Kuparuk
Colville
NATIONAL PETROLEUM RESERVE
Bowhead whale fall migration route

OIL EXPLORATION

Believing that the geology underlying ANWR's coastal plain may be as rewarding as other areas of the North Slope, the Interior Department puts the odds for finding commercially significant reserves in ANWR at 19 percent, with a 1-in-20 chance of finding another "supergiant" the size of Prudhoe Bay.

PIPELINE

Completed in 1977, the Trans-Alaska Pipeline currently delivers 25 percent of U. S. domestic oil supplies from North Slope fields. Yet with Prudhoe Bay's inevitable decline, experts believe the pipeline will be operating at only 25 percent capacity by the year 2000 unless new reserves are tapped.

Critical questions, changing answers

"... the Arctic National Wildlife Refuge is established and shall be managed ... to conserve fish and wildlife populations and habitats in their natural diversity including, but not limited to, the Porcupine Caribou Herd ...." *Alaska National Interest Lands Conservation Act, 1980*

Reporting as required to Congress, Secretary of the Interior Donald P. Hodel in 1987 recommended opening much of the sensitive coastal plain of ANWR to full oil exploration and development. Key conclusions of the final report, however, edited after public comment, show striking differences from the draft prepared by Interior Department field staff (A)—as well as sharp contrasts with concerns of the EPA (B) and a subsequent Interior Department study (C) on likely long-term damage to the ecosystem.

A DRAFT REPORT: Long-term losses in fish and wildlife resources, subsistence uses, and wilderness values would be the inevitable consequences ... development will result in widespread, long-term changes in wildlife habitats, wilderness environment, and Native community activities. [Development] could result in a major population decline [of the Porcupine caribou herd] and change in distribution of 20-40 percent, ... Because of the many variables involved and lack of relevant experience in estimating impacts on this herd and because of the difficulty of quantifying impacts, this estimate is uncertain.

FINAL REPORT: Impacts predicted for exploration and development drilling were minor or negligible on all wildlife resources on the 1002 area.

Potential major effects on wildlife from production are limited to the Porcupine Caribou Herd and reintroduced muskoxen.

A change in distribution of the [Porcupine caribou herd] could reasonably be expected. The potential for occurrence of a population decline ... cannot be predicted nor the size of a decline estimated. Nevertheless, there is a risk that a decline could occur. However, no appreciable population decline is expected as a result of oil development.

B EPA comments on final 1002 Report: The document totally ignores cumulative impact. ... Contaminants are totally ignored. ... Of the 21 [drilling mud reserve] pits for which effluent data were reported, 20 violated one or more effluent standards.

Contaminants are a major issue that deserves more attention.

Current EPA and Alaska procedures and regulations are adequate to ensure no significant deterioration of air quality.

Reinjection of drilling muds and other fluids, and careful construction will help reduce toxic spills.

C Fish and Wildlife Service draft report on Prudhoe and pipeline: Actual impacts to wilderness have been much greater than predicted due to the unanticipated demand for land. ... Fish and wildlife habitat losses resulting from construction and operation of the Pipeline System and Prudhoe Bay oilfields were greatly underestimated. .... Long-term and cumulative impacts have yet to be assessed, while additional impacts will continue to occur. ... A similar lack of predictive capability may be expected whenever development moves into new geographical areas. ...

The modification of approximately 12,650 acres (0.8 percent of the 1002 area) would be a minor effect on area vegetation and wetlands.

This Nation has proven that it need not choose between an improving environment on the one hand, and exploration and development of the energy resources required for growth and survival on the other. We can have both.

Circle, on the Alaska coastal plain in the Arctic National Wildlife Refuge (or ANWR, pronounced AN-wahr). Before us is the blue Beaufort Sea, studded with ice in late August. Around us lies a vast arc of reddening tundra, walled on the south by the white Brooks Range. Only here and along Canada's bordering coast do mountains come so close to this ocean, telescoping marine, coastal, and alpine ecosystems into a profile of the Arctic.

"If we're going to develop this," Tim declares, "we might as well go ahead and dam the Grand Canyon. You can make the same arguments for national energy needs. So why don't we? Because the nation has decided it's in its own best interests to preserve the Grand Canyon and find our energy elsewhere."

Is this refuge our Grand Canyon of the Arctic? And will development on its coastal plain alter it as surely as a dam floods a valley? That is an issue which Congress must judge.

Containing more than a fifth of the federal refuge system's total acreage, ANWR is often called North America's Serengeti for its size, pristine condition, and large, migratory Porcupine caribou herd. Set aside in 1960 as the

nine-million-acre Arctic National Wildlife Range, the refuge was given its present name and expanded to 19 million acres by Congress in 1980. Nearly half of it was granted wilderness status, which precludes mineral exploration and development.

ONLY IN ANWR is Alaska's Arctic coastline currently off-limits to oil leasing—105 miles out of 1,200. But much of ANWR's protected coast lies within what has come to be called the "1002 lands"—ten-o-two—for the pertinent section of the 1980 federal legislation addressing one and a half million acres of coastal plain and foothills. This coastal zone is the biological wellspring of an enormous ecosystem, shared with Canada, of which the refuge is only a part. Knitted by wildlife populations and native cultures, the region is above all made one by the 96,000-square-mile range of the Porcupine caribou herd, which gathers on the coastal plain for two critical summer months of calving and feeding.

In 1980 Congress left the future of the 1002 lands undecided, directing the Department of the Interior to evaluate their energy potential and the environmental impacts of oil development. In spring of 1987 a controversial report prepared by the department recommended immediate leasing of the 1002 area.

As chairman of the Alaska Coalition, Tim spearheads efforts to have the 1002 area declared wilderness. At our camp on the plain, in a prime target area for exploration, we walked out two by two, or alone, to feel the space of the tundra, measured by mountains at its nape and the sea at its feet. Low, voluptuous ocean clouds flew over the plain, trailing shadow and sunlight like rippling waves. Gossamer fields of cotton grass filled the air with downy seeds. A hunting trio of jaegers plunged in the wind, while a rough-legged hawk circled, uttering a thin, keening wail.

"You feel like you're walking on the curvature of the earth," observed Senator Wyche Fowler, Democrat from Georgia, camping with us on his summer vacation. "And if you kept walking, you'd come to the edge."

To an exploration geologist, it's an edge of a different kind: the chance of a lifetime to search for "elephants"—oil fields with more than a hundred million barrels of producible reserves—in perhaps the last major hunting ground on North America's mainland.

Footprints of the oil seekers will show in fragile tundra long after the wells run dry. To minimize damage, North Slope companies drill exploratory wells only in winter and confine production wells (top) to gravel pads, with wells drilled out at wide angles.

GEORGE STEINMETZ

A "mystery well" on native-owned land within ANWR was drilled by Chevron and British Petroleum during 1985 and 1986 with strict environmental guidelines. Even so, traces remained more than a year after reseeding began (bottom). But did they find oil? "The best kept secret since the A-bomb," says an industry magazine.

"THE DARK STAIN is actually oil," said Roger Severson of Chevron, chipping sandstone with his field hammer. A wind blew from the days of woolly mammoths; Roger and I hunched in our parkas and swiped at our noses. The lanky, thoughtful Californian handed me a piece of ancient riverbed redolent of crude oil: primordial and modern, the bittersweet smell of the 20th century on the Arctic breeze. Such signs first drew attention to Arctic oil.

A company helicopter had brought us to the 1002 area from Prudhoe Bay, North America's largest oil field. Beginning 40 miles west of the refuge, the industry's 20-year-old Arctic beachhead and four younger fields stretch for 60 miles along the coast. Connected by the Trans-Alaska Pipeline System (TAPS) to the port of Valdez on the Gulf of Alaska, they pump 2.2 million barrels a day—a fourth of the nation's domestically produced crude, one-eighth of daily consumption.

But more than half Prudhoe's 11 billion recoverable barrels are already gone.

"At the year 2000," Roger said, "with our known technology and producible reserves, the pipeline will be only 25 percent full. Soon the country will import more oil than it produces. That's why we need new reserves."

That is why, despite a worldwide sag in oil prices, exploration activity bustles over newly leased tracts of continental shelf in the Beaufort Sea. That is also why the industry has mounted its most intense lobbying effort of the decade, to open the 1002 lands.

Opponents like Tim Mahoney question the relative value of the estimated 3.5 to 9 billion barrels that ANWR might produce—half a year's national consumption at the low end.

"Some argue that conservation would make up that amount of energy," says Roger, "but conservation's not going to make new reserves. ANWR's not the only answer. But it's a significant part of the answer."

It is indeed only one piece in an energy mosaic emerging around the Beaufort Sea. A major find in the Canadian Beaufort promises future development there. On land in Alaska the Prudhoe-based complex continues to expand westward, while to its east, man-made islands tap new fields close to shore (facing page).

"There's a money bomb set to go off here," said a helicopter mechanic in ANWR. To the west of the refuge in the Prudhoe Bay field lies Deadhorse, where one exploded 20 years ago. Gateway to the oil fields and transport hub of Arctic Alaska, it can be a jarring sight after covering miles of wilderness measured in hours of flying—like waking up on the wrong side of town.

Heading west from the jetport, you leave the dumps and loading areas behind. Occasional clusters of orange, box-like wellhead housings signal that we are in the Kuparuk field, 30 miles from Prudhoe. With 1.9 billion recoverable barrels, it is second on the continent only to Prudhoe itself.

"You don't see any oil, hear any oil, don't see anything move. Just boxes," smiles Tony Kinderknecht of Standard Alaska.

Kuparuk's wells, ten to a 35-acre pad, slant out by directional drilling to siphon as much as four square miles of oil field. At the newer Endicott field, 70 wellheads set only ten feet apart on two artificial islands totaling 45 acres drain the continent's ninth largest reservoir, with 300 to 350 million recoverable barrels.

"This is development that's evolved into something very compact," Roger Severson told me. "It's very significant to look at in light of possible development in ANWR."

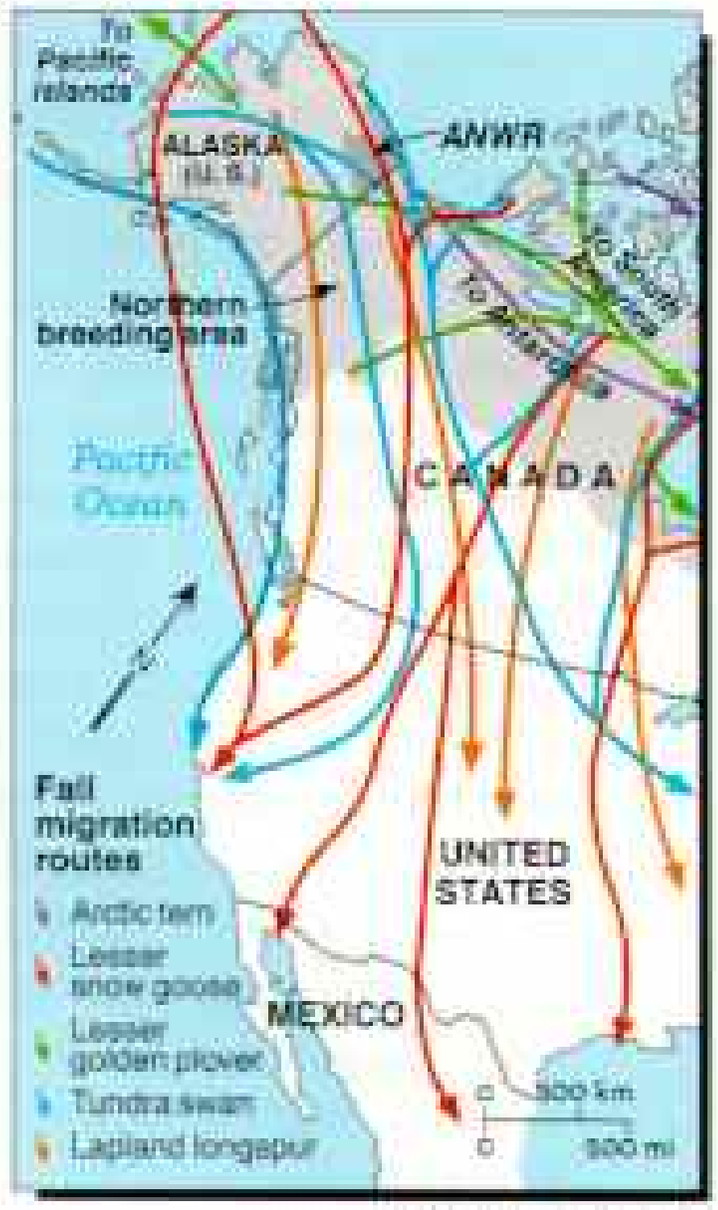
DÉJÀ VU HAUNTED ME beside the silent, gleaming pipelines. It called up the marshes of east Texas, not far from the Spindletop field where the modern industry was born. I hunted for many winters with my father and brother in those wetlands that seemed to grow oil wells and canals as natural features. Some of the ducks I bagged may have hatched here, on the North Slope's oddly familiar summer bogs.

The oil boom battered the Texas coast's wetlands with all the restraint of a gold rush. On the tundra the wildcatters' corporate descendants have moved more cautiously, and their performance wins high marks.

But the horizon is never free. It was troubling to imagine thousands of workers, and all the apparatus they control, transported to the untrammeled line of tundra on the 1002 lands. However fastidious its housekeeping, the oil complex is simply too large to avoid all impact.

A U. S. Fish and Wildlife Service draft report documented significantly greater impacts from the Prudhoe fields and the pipeline than were predicted in a 1973 environmental impact statement. New discoveries have since spread development over 800 square miles, an area half again as large as that anticipated.

State of the art in offshore drilling, the Endicott field (top) is a man-made island in the Beaufort Sea extracting 100,000 barrels a day. As at Prudhoe Bay (above left), an Endicott oil worker (right) divides his time between a space-age indoor environment and some of the harshest working conditions on earth.



NGS CARTOGRAPHIC DIVISION

Like rivers on the wing, birds from around the world flow onto ANWR's coastal plain each summer. Visitors include tundra swans, 30 species of shorebirds, and as many as 325,000 lesser snow geese (left) that migrate to the 1002 area to fatten on tundra vegetation. While staging for their long journey south, the geese are so skittish that a disturbance two miles away will flush them. Airplanes routinely traveling to and from oil outposts could reduce the flock's feeding time, weight gain, and migration survival rates. Similar fears are voiced about the polar bears, musk-oxen, and other mammals that inhabit the 1002 during vital stages in their life cycles.

Facilities cover 22,000 acres, while secondary effects such as release of contaminants reach a much wider area. Dumping of sewage and spills of oil and other toxic materials have been more frequent than predicted. And studies have indicated that organic pollutants affect the food chain in ponds hundreds of feet from leaking "reserve pits."

Air-quality standards are met, but critics question whether levels set in the lower 48 are low enough to protect the fragile Arctic. At Prudhoe the world's largest assemblage of gas-fired turbines pumps nearly as much acidifying nitrogen oxide into the atmosphere as the state of Delaware. If questions about existing development are unanswered, the implications of further industrialization in the 1002 lands remain largely unaddressed.

"The 1002 report was basically biological," said Larry Dietrick, North Slope manager and now director of Alaska's Division of Environmental Quality. "What they didn't do was look at air, water, and waste disposal at Prudhoe. They want me to write stipulations for ANWR, but the groundwork isn't complete. What we need is a 1002 report for air and water before Congress makes its decision."

"We're only 20 years into a 50-year experiment in Arctic development," state biologist Ken Whitten points out.

LONG-TERM EFFECTS of 1002 development on wildlife is another source of unease. Sheaves of reports have discussed the example of Prudhoe Bay, where caribou of the central Arctic herd feed beside roads, and the herd, which lives in the vicinity year-round, has increased from 5,000 to 18,000 head in the past 15 years. But conclusions cannot be quickly drawn.

Within a mile of roads or facilities in Prudhoe Bay, calving by the central Arctic herd has been cut in half. In the 1002, exploration is targeted in several hundred thousand acres of prime calving and feeding grounds for the 170,000-head Porcupine herd. Long-term effects on productivity cannot be predicted for the migratory Porcupine animals, larger in numbers than the central Arctic herd and dependent on a segment of coastal plain much narrower than Prudhoe's.

Curiously, caribou herds worldwide have grown in the past decade. Cyclic increase and reduction seems to be natural. But no one can fully explain why.

"We don't want to be subjected to life in a lonely Arctic ghetto," says Oliver Leavitt (top), vice president of the native-owned Arctic Slope Regional Corporation. Created by native land-claims legislation in 1971, ASRC parlayed land and mineral rights into "dramatic improvements" in the lives of its shareholders, largely through lucrative deals with Prudhoe Bay oil giants. ASRC also holds mineral rights to 92,000 acres in the 1002.

"We are subsistence hunters," says Nolan Solomon (bottom), a whaling captain in Kaktovik, an Eskimo coastal village near ANWR potentially affected by offshore drilling and seismic blasts. "The whales have very good hearing," Nolan explains, displaying the ear bone of a bowhead whale.

At the height of summer a spectacle occurs on a scale not seen in the lower 48 since the buffalo truly roamed. Soon after the calving, bulls join mothers, yearlings, and young, and the whole free-ranging herd is strewn across the green coastal plain, perpetually on the move.

It is a crucial time of building fat. But these are the misery months of mosquitoes and flies. On the worst, windless days stupendous aggregations of caribou school like fish, as many as 80,000, and often move en masse to beaches in search of breeze and relief. Large groups in existing oil fields are often reluctant to cross busy roads next to pipelines. If large-scale 1002 development interferes with normal movement, loss of feeding grounds and relief from mosquitoes could cause a decline in nutrition and overall health.

"An oil field is complex," cautions Dr. Dave Klein of the University of Alaska at Fairbanks, "but we can understand it well enough to make it work. In the case of ecological relationships, the complexity is far greater."

NO ONE CARRIES a deeper knowledge of those complexities than the Eskimos of this coast. They also know the difficulties of their own transition from an ancestral to a modern world. Where once they depended on seal and caribou, life today is fueled by oil.

A billion dollars reaped in taxes on oil development in the past decade have transformed daily life for the 4,800 residents of Alaska's North Slope Borough, scattered across the Arctic in some of earth's loneliest communities. They financed new oil-heated houses, gravel roads, electricity, and services such as "honey bucket" sewage pickup, new schools, modern clinics, and satellite TV. They also paid for new jobs and construction-work wages that averaged $26 an hour.

"We've become Americans," said Oliver Leavitt, an Eskimo a long way from his log-cabin beginnings, in a glass office building in his hometown of Barrow, population 2,850. As vice president of the Arctic Slope Regional Corporation (ASRC), Oliver helps steer the ninth largest corporation in Alaska—and among the most profitable of 13 native-owned regional corporations, thanks to oil.

As shareholders, North Slope Eskimos have a stake in its fortunes, which Oliver believes depend on 1002 development. Both borough and corporation have felt the pinch from slumping oil prices, with borough revenues down 20 million dollars in 1987. A boom in ANWR means new blood, and most Eskimo leaders are vigorously in its favor.

But the choice is not a simple one viewed from Kaktovik, an Inupiat Eskimo village of 200 in the heart of the 1002 area's coast. Sleet squalls cross the gray-green lagoon, draping the village in gauze. It seems herded onto its knoll, feet drawn up from the sea—prefab houses, packing-crate add-ons, Quonset huts, a modern school, and the scoop towers of radar like strange cathedral spires. These are the steel sentinels of the Distant Early Warning (DEW) System. The military presence first appeared in the 1940s, eventually forcing the village to move three times, like a harbinger of changes to come.

"You're seeing a mandated change in lifestyle, produced by money," said Kaktovik's Mayor Loren Ahlers, a California farm boy who came to work at the DEW line in 1967, married, and stayed. "These people have grown to a modern world since I've been here. They have electric bills and house payments. It's a cash economy. You can't go backward."

The village is on Barter Island, between the plain and the Beaufort Sea, a trading crossroads far back into prehistory. To the Eskimos the plain is a birthright, a source of food, and now maybe a door to prosperity. They stand at ground zero of the coming boom. But the prospect brings anxiety, uncertainty.

"All the permanent jobs are filled," said Susie Akootchook, village-council secretary, whose two teenagers would soon finish high school. "Development would bring jobs. But I'm afraid it will hurt the land."

At Kaktovik's clinic I met a young woman who held a firmer view. "I wish they'd just stay the hell out of here. There'd be drugs and alcohol coming in like crazy; scare all the animals away, and stuff like that. But we know it's going to come whether we want it or not."

The local government, reckoning this new force as irresistible as the DEW line, reversed initial opposition and endorsed 1002 development if the surviving Eskimo "subsistence" life is protected when roads come. Many villagers still rely on traditional food: Dried caribou hangs in modern kitchens, and fish fill electric freezers. Half or more of most families' meat, fish, and fowl still comes from the land, says biologist Sverre Pedersen.

And from the sea, at the hands of leaders like

Nolan Solomon. A taut, quiet man, Nolan is a Kaktovik whaling captain and serves on the Alaska Eskimo Whaling Commission. He holds out a strange rounded bone like waxed ivory, twice as large as his fist.

"This is a whale's ear. They can hear a thousand miles. They hear you as soon as you go out on the ocean."

The ear bone is from a bowhead he harpooned from his open motorboat 20 miles offshore. Although the species is endangered, the village is allowed three strikes a year under a native hunting quota. But a whale struck and lost is one gone without.

Nolan was assembling explosive harpoon heads on his living room floor. Radio transponders track the harpooned animals. From his boat he can speak to Prudhoe Bay by ship-to-shore radio for weather and traffic updates. (Oil companies sponsor the system to minimize conflict between native whaling and exploration activity.) Like so many pursuits on the northern frontier, whale hunting applies the new technology to a life rooted in the Ice Age.

The whaling season lasts from September into October as the bowheads migrate past. A successful captain receives the honor of distributing the meat and muktuk, whale skin and blubber, in an established order that includes the whole village. "That's the captain's pride, to feed all the people," said Nolan Solomon. "When we get a whale, all of a sudden there'll be 200 people on the beach."

But "the ocean is real sensitive," as Nolan told me, and so is the luck of a whaler. The season drew on, and polar bears came ashore to roam the airstrip. By late September my last sight of Kaktovik was a mother and two cubs prowling a sandbar near the hangars. Soon after I left, autumn did too; ice covered the ocean and the lagoon, and Kaktovik went into winter without a whale.

IN BARROW I asked Oliver Leavitt about the future of his people on that distant day when the last well is dry. He answered with one word: "Coal." Thick seams, comparable in magnitude to those of the entire lower 48 states, underlie much of the North Slope. Along with huge deposits of natural gas, they represent energy not yet badly enough needed to pay its own way to the ravenous South. But its day will come, and present decisions will be planks of future policy.

Not all the region's natives expect to dine at oil's table. In the south of the Brooks Range, nestled in a crook of the refuge's border, lies Arctic Village, reachable only by air or taiga trail—arguably the most isolated Indian village in the nation. Much of the diet is meat, and three-quarters of it comes from the Porcupine caribou herd. If numbers decline or migration routes change due to 1002 development, life will change for Arctic Village's Gwichin Athapaskan Indians and their close Canadian kin over the border in Old Crow, whose existence revolves around hunting and meat.

"People are making decisions in Washington, D. C., that are gonna affect our land. The caribou, that's what we eat, it's like our body," said 33-year-old hunter Kenneth Frank. Caroline, his wife, is an aide at the village school where she hopes someday to teach.

"Nobody around here has a hangover," said Kias Peter, a hunter who was my host for four days. Alcohol has never been tolerated since Arctic's founders, strong hunters and Anglican believers who migrated from mountains to valleys, began settling here at a summer fishing hole early in this century.

"Whenever you get meat from the land, it costs a lot of work," said Kias, carving steaks from a furred haunch. "Sometimes caribou don't come around. That's when we have to buy meat from store. Meat with stamp on it."

Every ounce of food not taken from the land arrives by plane. Without plentiful caribou, the cost of eating would likely make life in the village untenable. The perceived common threat to their herd united Gwichin across the border in June of this year for the first cross-border tribal gathering since free passage and barter of food ended with security restrictions during World War II. In a formal statement they declared that "the very future of our people is endangered by proposed oil and gas exploration and development in the calving and post-calving grounds in the Arctic National Wildlife Refuge."

In Alaska the Gwichin stand virtually alone in opposing development. In Canada, on the other hand, native communities have received full support from the federal and territorial governments in their objections. Oil exploration has revealed a billion-barrel prospect in the Canadian Beaufort that may someday pay for a pipeline to the South, but no commercial reserves have been found on Canada's North Slope. A 1984 federal lands-claim settlement with the Inuvialuit—the Inuit, or Eskimos, of

Canada's western Arctic—made wildlife conservation and subsistence hunting the top onshore priorities, overseen by an Inuvialuit-controlled game council.

The settlement created the three-million-acre Northern Yukon National Park on ANWR's border to protect the Canadian portion of the Porcupine herd's calving ground from any future development. Canadian officials have cried foul over U. S. government support for 1002 development, citing a recently signed binational agreement to protect the herd and its habitat.

In the park I felt an atavistic calm when I walked through calving herds on a softly sunlit night. Later, rafting the Firth River with guide Martyn Williams and a convivial group, I felt the mood grow quiet as we traversed a treeless land with no place to hide.

For the good of his grandchildren, Inuit leader Billy Day helped win a native land-claims settlement in Canada that made wildlife conservation and subsistence hunting top priorities on the Yukon side of ANWR's border. Questioning the oil-money life-style, he remembers when nearby offshore drilling was phased out: "People thought this was something that would never end," he says.

AT A SUMMER CAMP for hunting beluga whales in the Mackenzie River Delta, I met Billy Day (right), an Inuvialuit leader who helped negotiate the settlement that created the park and gave his people unprecedented control over their land. Jut-jawed and broken-toothed as an old beluga whale, Billy has a brown-sugar smile for the grandchildren who surround him.

"From now until eternity, any child will be a part of that claim," he said.

Billy's youngest son, 17-year-old Linley, sat with me on the bluffs in twilight, slapping mosquitoes and watching for the telltale spouts of beluga whales on the bay. He left school after third grade, growing up with a bush education at his father's camps. He told me how to catch beluga whales, and the price of furs, and how to navigate in fog, and about the ghosts heard here—voices from tundra graves nearby, and a baby that cries at summer's end, when the first darkness comes.

The dead are always close by on this coast. On a midsummer midnight on Herschel Island, now a territorial park staffed with Inuvialuit rangers, I stood at a driftwood grave and a skeleton bared by time, from long before white whalers arrived here a century ago. The newcomers devastated bowhead stocks for baleen to stiffen Victorian corsets, and brought alcohol and disease to Inuvialuit who flocked to whalers' winter quarters on Herschel.

The sun hung low over the Pole and threw a golden shaft across the island and the plain to spotlight the Firth's canyon where it leaves the mountains. Near that point a rock juts from the tundra, 265 feet above the river valley. The Porcupine herd migrates past this rock, and hunters have gone there to spy caribou and waylay them for as long as men have hunted this coast. Artifacts found at the rock's feet cannot be dated to reveal the order of the cultures that left them, for frost has heaved them into random levels in the soil.

Anything buried on this coast, I realized then, will someday be resurrected. There is about it something of the eternal, or something as close as we may ever glimpse, and deeds done now will be read in the book of the land for longer than we know. □

Whales

An Era of Discovery

No longer must we kill whales to study them. That is the most important thing we have realized about whales in the past two decades, an era that has vastly increased our knowledge of the living whale.

That the whale is a mammal is not new. But new and exciting insights into behavior and genetics reemphasize the strong parallel with land animals.

To know whales as individuals once seemed impossible. Now we have cataloged thousands by their markings, and even named them. We marvel at whale courtship and mating strategies, map the ocean freeways they travel, and try to parse their acoustic messages.

And we know that sometimes they simply play, like this young upside-down humpback reaching for the sun in Hawaiian waters.

MEGAPTERA NOVAEANGLIAE, ADULTS 50 FT, 40 TONS

By JAMES D. DARLING

Photographs by FLIP NICKLIN

Eye contact with a precocious southern right whale off Argentina led to a spine-tingling experience for photographer Nicklin. After he patted the young whale, it began repeatedly rubbing

EUBALAENA AUSTRALIS, ADULTS 50 FT, 60 TONS

the length of its body against him "like a house cat —no, like a 30-ton cat the size of a house." Hunted nearly to extinction, this species is recovering very slowly.

Aligned like sleek aircraft, a killer whale family group rests in British Columbia's Johnstone Strait. Here they have turned off the active sonar by which they navigate, staying

ORCINUS ORCA, 25 FT, 8 TONS

in close contact instead. These toothed whales belong to pods that have remained permanent for 20 years, each pod with its own dialect of calls.

Speed, power, and grace surface in the Gulf of California as a fin whale comes up for air. One of the swiftest of the great whales, able to exceed 20 knots, fins left whalers in their wakes

BALAENOPTERA PHYSALUS, 70 FT, 45 TONS

until steam-powered catcher boats caught up with them in the late 1800s, slashing an original world population of more than half a million to about 120,000 today.

Tusked torpedoes, male narwhals crowd a narrow lead in Lancaster Sound as summer ice breaks up in the Canadian Arctic.

The land creatures that went to sea

MANY SCIENTISTS HAVE LONG FELT that whales, mammals gone to sea and uniquely adapted to that foreign environment, resemble no living land mammals and therefore should not behave like them. That attitude is shifting.

The ancestors of modern cetaceans were probably large land creatures called mesonychids, below at left, that lived in the Paleocene epoch, about 60 million years ago. Dwelling along lagoons and estuaries, they evolved toward the aquatic existence inherited by their successors. From one of these intermediate ancestor families, today's toothed and baleen whales began to diverge some 25 to 30 million years ago, branching into nearly 80 species now recognized.

Whales' closest living relatives belong to another group of mammals that stayed ashore—the artiodactyls, or even-toed

MESONYCHIDAE

CETACEA

BALAENIDAE

RIGHT WHALE

ARTIODACTYLA

BALEEN

BALAENOPTERIDAE

TOOTHED

ESCHRICHTIIDAE

PHYSETERIDAE

MONODONTIDAE

ZIPHIIDAE

DELPHINIDAE

PHOCOENIDAE

PLATANISTIDAE

PILOT WHALE

KILLER WHALE

BELUGA

BAIRD'S BEAKED WHALE

HARBOR PORPOISE

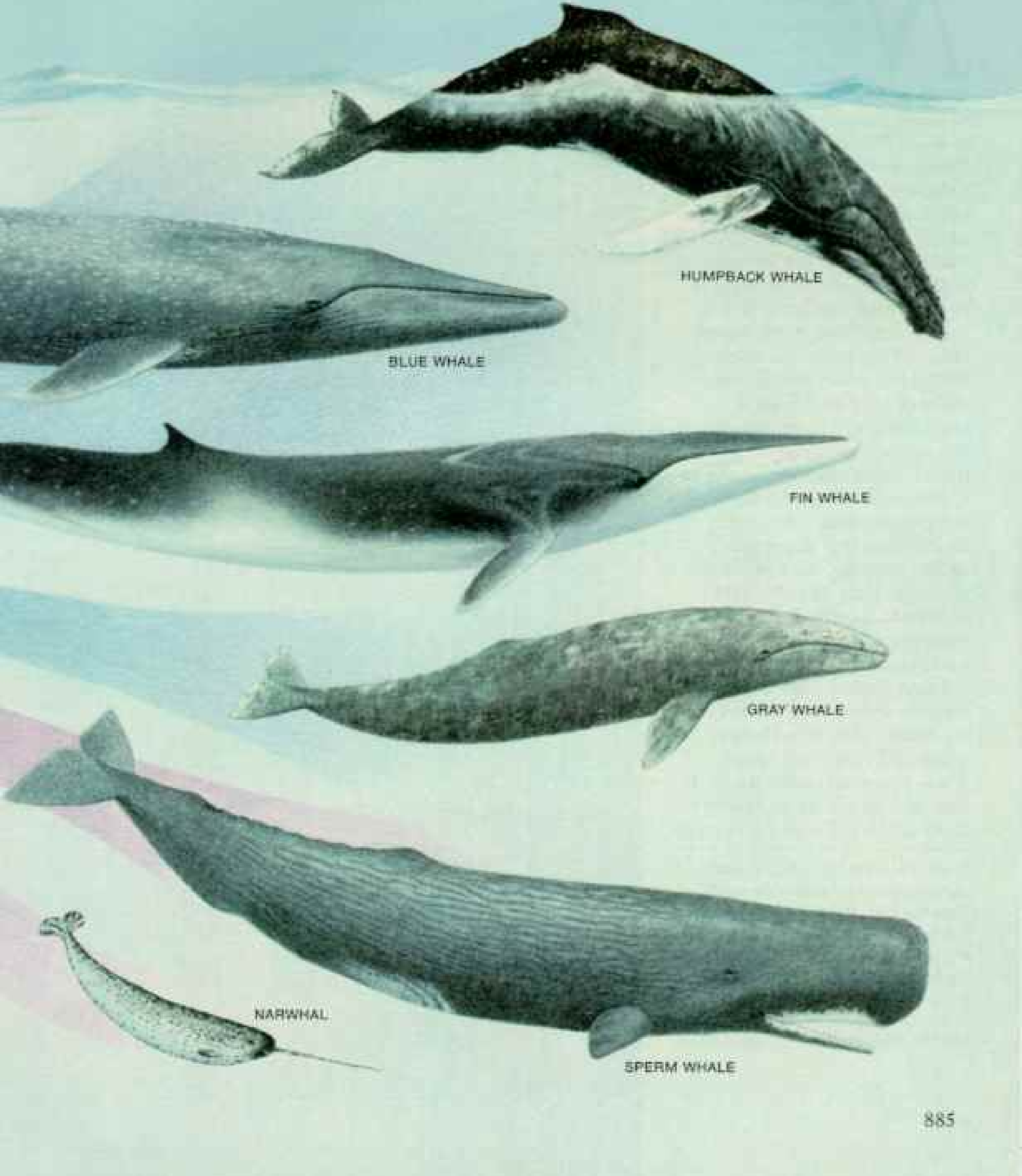
BOUTO

BOTTLENOSE DOLPHIN

PAINTING BY LARRY FOSTER

ungulates such as deer, sheep, bison, pigs, camels, and cattle. Recent research in molecular biology by Vincent Sarich and Jerold Lowenstein found that one of the artiodactyls —the hippopotamus—is probably the land mammal most akin to whales.

Biologists are seeing new connections between whales and their counterparts on land. Peter Thomas and Sara Taber describe behavior between right whale mothers and calves as comparable to moose, musk-ox, and caribou. I interpret mating activity in humpbacks as similar to that in Rocky Mountain bighorn sheep. Randall Wells sees parallels between bottlenose dolphin and lion societies, and Hal Whitehead suggests that sperm whales' mating system is much like that of African elephants. Whales, we are realizing, are mammals first, ocean dwellers second.



Working with Whales

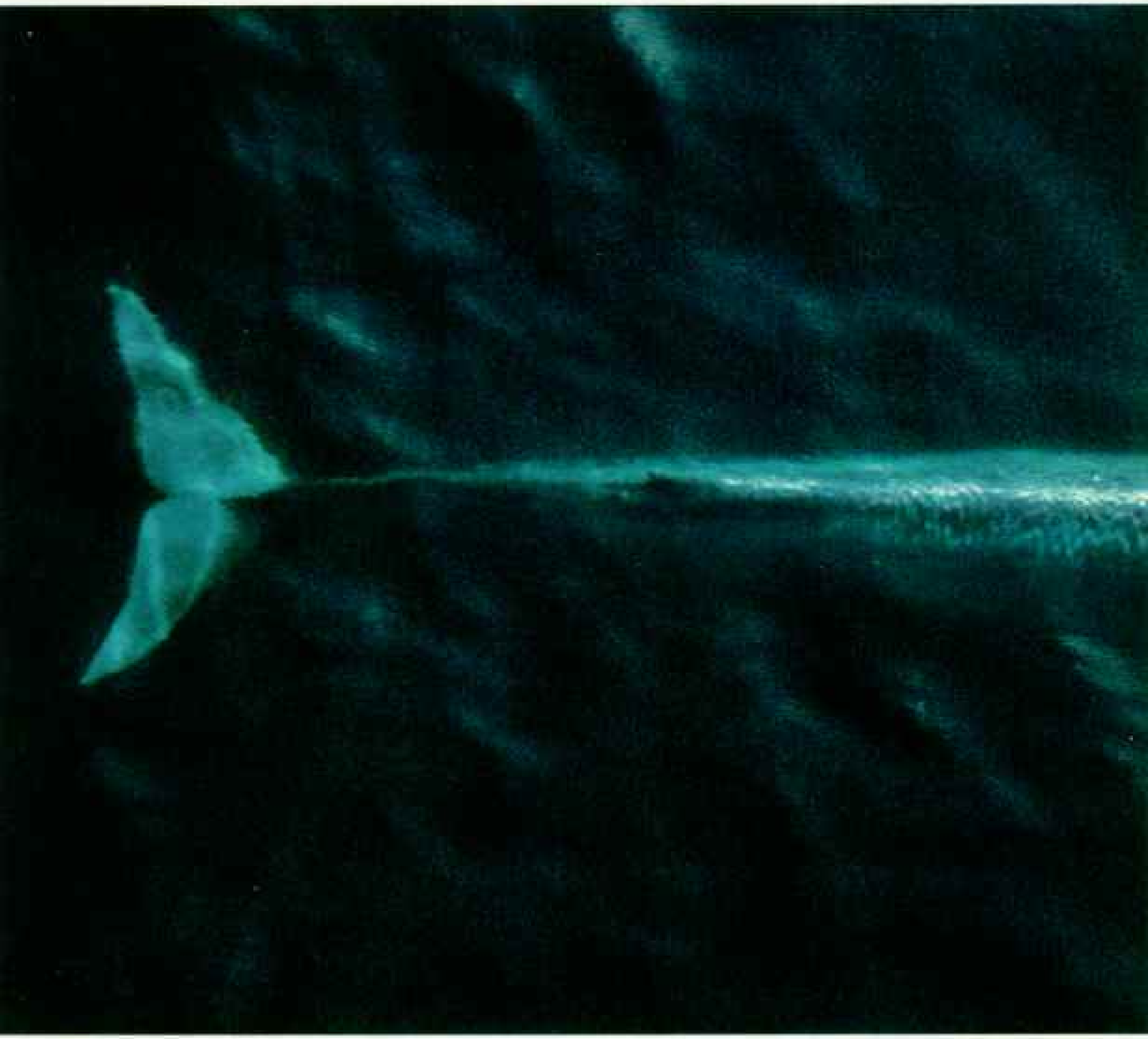
NOT ALWAYS SHY, whales have a way of getting our attention. Off Argentina's Península Valdés, a southern right whale raises its flukes as if in greeting to Roger Payne, right, Argentine student Gustavo Alvarez Colombo, center, and me, at left. Roger believes that such behavior can lead to a whale's "sailing" by catching the wind with its tail. One of the deans of modern whale research, he has observed the right whale population off the peninsula since 1970. Here adults return from the open sea each winter to calve and mate. Roger was among the first to demonstrate the feasibility of nonlethal research by building a file on these individual whales, identifying them by patterns of growths called callosities. He and his former wife, Katy, then brought wonder to the world with their description of the songs of the humpback whale.

I have known Roger since 1975 when he served as an adviser for my master's thesis on the gray whales off Vancouver Island, where I now live. With Roger, I then took part in a cooperative study of North Pacific humpbacks.

JAMES D. DARLING's humpback study helped him earn a doctorate from the University of California at Santa Cruz. He is now executive director of West Coast Whale Research Foundation. The outstanding pictures for this article add to FLIP NICKLIN's reputation as one of the world's leading whale photographers.

"If [ocean] noise is really increasing because there is more shipping, it may have a negative effect on maintaining the population of the whales that depend on the long-distance propagation of low-frequency sound."

—William A. Nierenberg, Director Emeritus, Scripps Institution of Oceanography



LIKE A LOVELY ARROW more than 80 feet long, a blue whale glides through the Gulf of California. This largest of all whales is studied by Richard Sears and Martine Bérubé (far right), using data assembled since 1979 on a separate blue whale population in the Gulf of St. Lawrence. The group he founded, the Mingan Island Cetacean Study, has identified 300 blue whales by pigmentation patterns on their sides.

Biologists have successfully radio collared and tracked most endangered terrestrial animals. Whales represent the last frontier. The sea plays havoc with electronic gear, and whales cannot be tranquilized. Moreover, they do not come equipped with necks or convenient appendages to hold transmitters. On the verge of a solution is Bruce Mate of Oregon State University (right). One of his whale-wiring strategies involves a small helicopter carrying a camera so he can track the craft with a monitor, in his left hand. He hopes to land the helicopter gently on a whale's back and release a transmitter the size of a large coffee cup that would implant itself with stainless steel sutures, mimicking a barnacle's attachment. Without the helicopter, Bruce has successfully hand-attached the device—which relayed its data via satellite—on whales stranded or otherwise accessible. "In a few years," he predicts, "several species will be satellite tagged. Field researchers with laptop computers will be able to pick up a pay phone and get the animals' locations and dive data for the previous week."

BALAENOPTERA MUSCULUS, 80 TO 100 TONS

INDIAN OCEAN

ASIA

PACIFIC OCEAN

AUSTRALIA

ARCTIC OCEAN

NORTH AMERICA

SOUTH AMERICA

ANTARCTICA

WHALING

Aboriginal subsistence

Nations killing whales under IWC allowance for scientific research

- Japan
- Norway
- Iceland

In 1979 the International Whaling Commission declared a ten-year ban on commercial whaling in most of the Indian Ocean.

COMMERCIAL FISHING
Despite efforts to reduce mortality among dolphins caught in purse seines along with yellowfin tuna in the eastern Pacific, about 100,000 dolphins still die each year.

WHALING
Even though an international pact bans commercial whaling, some nations still kill whales under a provision for scientific research, and aboriginal peoples hunt them for subsistence.

SELECTED WHALE DISTRIBUTION

- Narwhal
- Right
- Humpback
- Known humpback migration route
- Probable humpback migration route
- Probable right whale migration route

Siberia (U.S.S.R.)
Alaska (U.S.)
Canada
Greenland (Denmark)
Iceland
Norway
Vancouver Island
Baja California, Mexico
Gulf of California
Gulf of Mexico
Caribbean Sea
Central America
Galápagos Islands
Dominican Republic
Hawaii
New Zealand
Japan
North Pole
South Pole
Lancaster Sound
Bering Strait
EQUATOR

Can whales recover?

"TODAY THEY MAY BE HEADING toward the same fate that pursued the once-vast herds of American buffalo. Three-quarters of a million whales have been killed since 1900." Remington Kellogg, an eminent biologist, sounded that warning in 1940 in the first comprehensive article on whales in the GEOGRAPHIC. Since then, another half million carcasses have been winched aboard factory ships, although the era of commercial whaling may at last have ended. Fifteen years ago 45,673 whales were killed; by 1985 the number had plummeted to 6,623 annually. The following year the International Whaling Commission (IWC) declared a five-year moratorium on commercial whaling.

Some species, particularly humpback, bowhead, blue, and right whales (table, below), had been hit harder than others, and some seem to be recovering slowly, such as right whales. It was encouraging when Scott Kraus of the New England Aquarium discovered a new calving ground for that species in 1985 off Georgia and Florida. Several whale sanctuaries have been established—in lagoons of Mexico's Baja California, Golfo San José in Argentina, the Dominican Republic's Silver Bank, Robson Bight off Vancouver Island, and most of the Indian Ocean—and others have been proposed.

Subsistence hunting is still done by Alaska natives, who kill about 30 bowheads a year, and by aborigines of Canada, Greenland, and Siberia. Some nations have taken advantage of a loophole in IWC regulations to continue whaling under the guise of scientific research, perpetuating the myth that only dead whales can teach us how they live. Japan targeted 300 minke whales last year, Iceland 80 fin whales and 20 sei whales. In retaliation the United States has barred Japan from catching fish in U. S. waters. Norway last year made about 300 commercial kills of minkes. Meanwhile, research at Cambridge University suggests that social structure, paternity, and breeding information for whale populations may be obtained by molecular analysis of small skin samples, a technique that, if proven, could put the scientific whalers out of business for good.

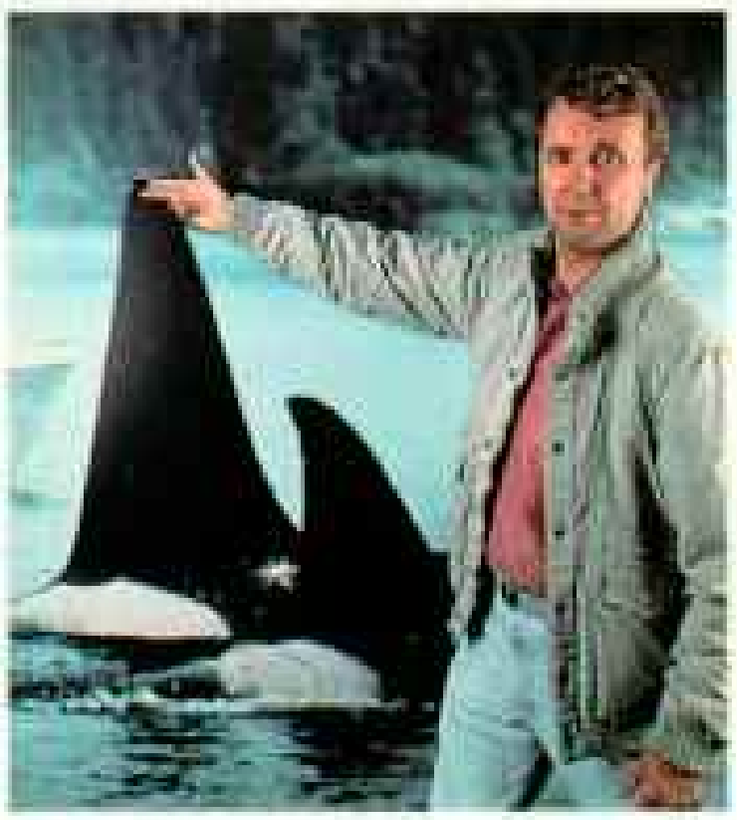
WHALE POPULATIONS

Species	Status	Pre-exploitation Numbers	Present Numbers	Main Diet
Beluga (**B**)		100,000 +	50,000 +	fish, crustaceans (t)
Blue (**Bl**)	E,P,R	200,000 +	5-10,000	plankton (b)
Bowhead (**Bo**)	E,P,R	65,000	8,000	plankton (b)
Bryde's (**By**)	P,R	*	*	fish, plankton (b)
Dolphins (**D**)	†	*	*	fish, squid, crustaceans (t)
Fin (**F**)	E,P,R	500,000 +	120,000	plankton, fish (b)
Gray (**G**)	P,R	24,000	21,000	crustaceans (b)
Humpback (**H**)	E,P,R	125,000 +	12,000 +	plankton, fish (b)
Killer (**K**)		*	*	fish, mammals (t)
Minke (**M**)	P,R	350,000 +	350,000†	plankton, fish (b)
Narwhal (**N**)		*	30,000	fish, squid, crustaceans (t)
Pilot (**P**)		*	*	squid (t)
Porpoises (**Po**)	†	*	*	fish, squid, crustaceans (t)
Right (**R**)	E,P,R	50,000	3,000	plankton (b)
Sei (**S**)	P,R	250,000 +	50,000 +	plankton, fish, squid (b)
Sperm (**Sp**)	P,R	2,000,000 +	1,000,000 +	squid, fish (t)

Abbreviations represented on map in bold type
E—Endangered
P—Protected
R—Regulated by IWC
Population numbers highly speculative
*No data
†Some species endangered
(t) Toothed whale
(b) Baleen whale

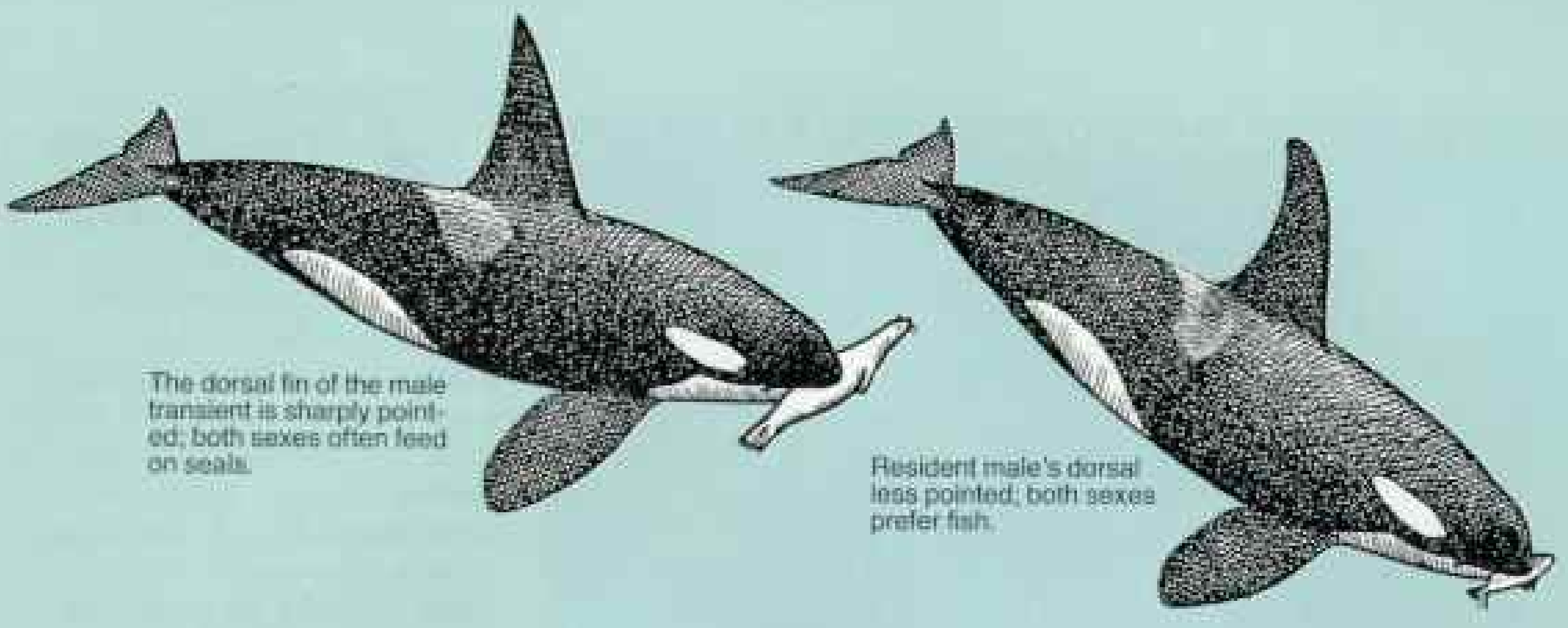
"WHEN YOU EXPLAIN that killer whales are animals with a complex social arrangement, that they stay together all their lives, and that we can identify them as individuals—people relate readily to that." Thus Mike Bigg, a marine mammalogist with Canada's Department of Fisheries and Oceans, describes the appeal of his favorite subjects since 1971. He points to a photograph of a male's tall, triangular dorsal fin, distinguished from the smaller curved fin of an adjacent female. After amassing more than 60,000 photographs, Mike and several colleagues have used more subtle characteristics of those fins, as well as white "saddle patches" around them, to identify a population of about 330 killer whales in British Columbia waters.

Researchers have opened an extraordinary window into the lives of these Canadian whales, composed of both resident and transient communities (facing page) divided into extended family groups called pods. Killer whale society is the most stable known of any social mammal. "If you are a resident killer whale, male or female, one of the laws of social organization is that you are going to stay with your mother throughout her life," Mike notes. During a 20-year study, British Columbia pods have remained permanent, except for births and deaths. They consist of as many as four generations of related whales of both sexes—great-grandmothers, grandmothers, mothers, sisters, and their offspring, including mature males.

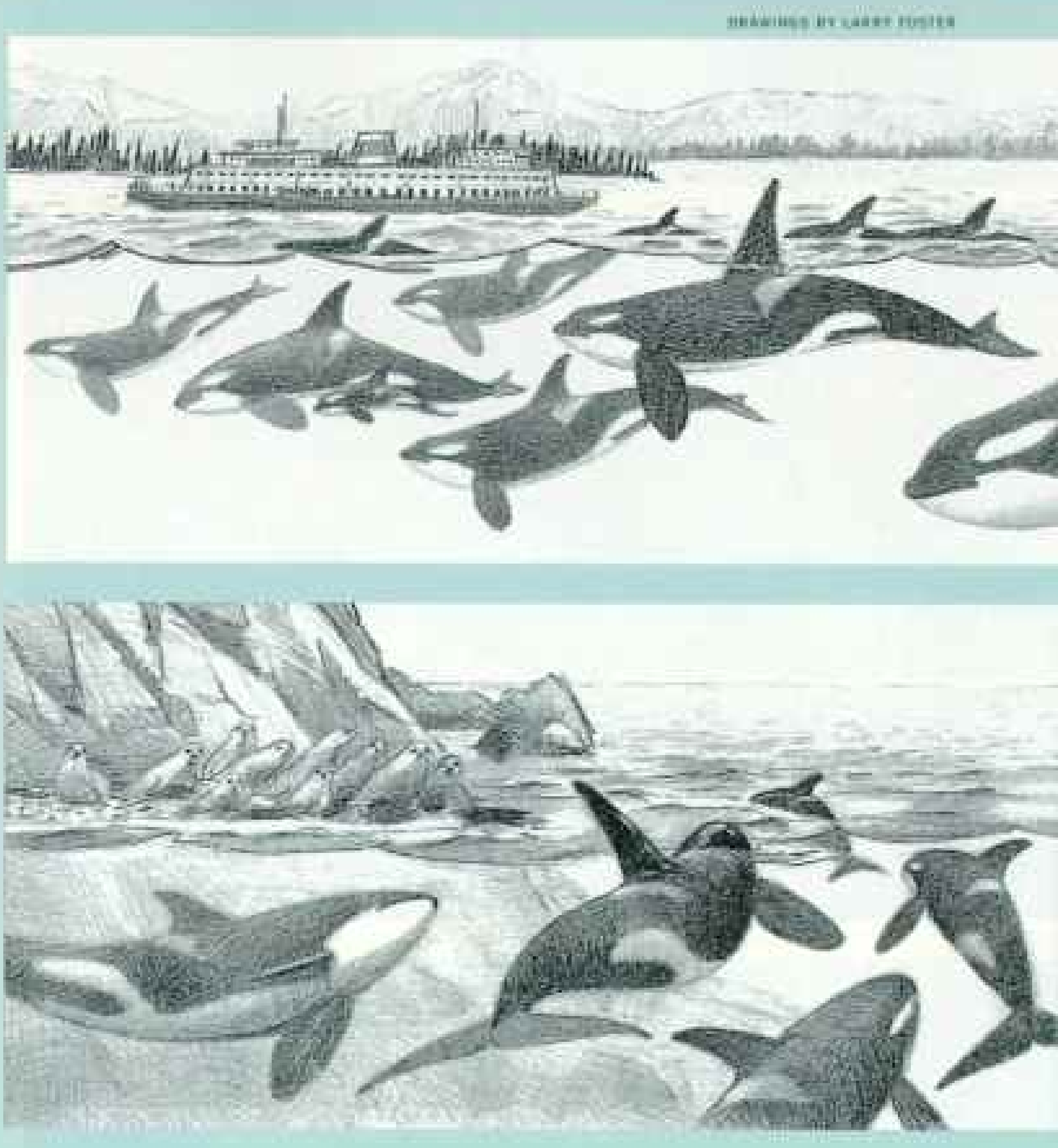


Cows mature sexually at roughly age 15, but give birth at very different rates. The average is about one calf per cow every five years, an extremely low birthrate. But the killer whale's natural mortality rate is also very low, one percent a year for cows, 3 percent for bulls. Cows may live as long as 80 years, bulls about 60. Thus it takes a very long time for killer whale families to disperse and for new ones to come together.

A young killer whale breaches, to the delight of Johnstone Strait whale watchers (below).



DRAWINGS BY LARRY FOSTER



Killer whales at home and on the move

TWO LIFE-STYLES distinguish British Columbia's killer whales. One resident group, the northern community of 175 whales, ranges from mid-Vancouver Island to the Alaska Panhandle. Also residents, the southern community of 80 whales extends to the Washington coast. A third group called transients, 75 whales, roams a long stretch of coast including the territories of the resident groups. Transients travel in small pods of six whales or fewer and hunt large prey such as seals (above)—as wet-suited surfers can attest after having been closely inspected by transients. Larger pods of residents fish for salmon (center). Transients' dorsal fins are more pointed than those of residents (top).

As AFRICA'S PLAINS offer different plant communities for zebras, giraffes, and wildebeests, so the sea has its own ecological niches filled by whales. Baleen whales are its great grazers, seeking krill and other tiny prey with different feeding strategies in different ocean strata. With a cavernous maw, a skim-feeding right whale vacuums the surface for copepods (top left). Bowheads also browse this way, and California researcher Bernd Würsig has seen them feeding in the Arctic in V-shaped echelons of as many as 14 whales, "like a flight of geese."

A humpback lunges forward to trap small fish or krill in southeast Alaska waters (left). Humpbacks, as well as blue, fin, and minke whales are known as gulpers, filtering great sea swatches a mouthful at a time. Humpbacks also perform the wonderful specialized technique called bubble netting, first described by Alaska researcher Charles Jurasz. I recently saw a pair of Alaska humpbacks spinning their "net" by blowing a circular column of bubbles to surround and concentrate a patch of krill, followed by an explosion of open-mouthed whale surfacing amid the net.

Gray whales make their living mostly on the bottom, vacuuming sediments to take in mouthfuls of mud and invertebrates, then expel clouds of silt, like this gray off Vancouver Island (left).

Unlike the baleen families, many toothed whales such as this pilot whale—scarred perhaps by courtship battles and predators (right)—have echolocating sonar to pinpoint their prey, including squid. More pilot whales have been stranded ashore en masse than any other species, a phenomenon for which we have many ideas but still no consensus.

GRAY WHALE, *ESCHRICHTIUS ROBUSTUS*, 40 FT., 80 TONS; SHORTFIN PILOT WHALE, *GLOBICEPHALA MACRORHYNCHUS*, 18 FT., 1.8 TO 3.3 TONS

WHALE tormentors make life miserable for these seemingly imperturbable giants.

"Sea fowls are pecking at the small crabs, shell-fish, and other sea candies and maccaroni, which the Right Whale sometimes carries on his pestilent back." Herman Melville's observation is borne out by Peter Thomas, who studied the species off Península Valdés and saw the damage inflicted by an apparently innocuous kelp gull.

"The gulls land on the backs of whales, usually mothers with calves in shallow water," Peter reported. "Their backs are sunburned and beginning to peel. The birds lift up sheets of peeling skin or gouge into deeper layers underneath. This drives the whales crazy. The mothers flinch, their heads and tails come up, and they breathe explosively (below)." Reminiscent of oxpeckers, African birds that pick parasites from large mammals' hides, the gulls sometimes methodically harass half a dozen resting mothers and calves that suddenly make the water boil.

Less painful but more burdensome are the barnacles and other hitchhikers that can festoon a whale like a moving island. In the Gulf of California, pseudo-stalked barnacles cling to a blue whale's dorsal fin (below), while remoras ride below as commensal feeders that share table scraps. Some barnacles reach their peak density in cold water and tend to drop off in the tropics. At the end of a summer in polar latitudes a humpback may have accumulated as much as half a ton of hard-shell barnacles.

A more serious threat may be posed by the myriad species of internal parasites that afflict baleen and toothed whales. They can live almost anywhere, including the stomach, intestines, kidneys, liver, lungs, and brain. Tapeworms can reach 50 feet, and one sperm whale's stomach contained 110 pounds of nematodes. Such organisms may increase mortality rates, especially of smaller species.

While sharks may prey on dolphins and their small relatives, the only animal besides man of which healthy large whales must always be wary is the killer whale—indeed they were once called "whale killers." Their attacks have been documented on gray, humpback, blue, right, Bryde's, minke, sperm whales, and narwhals, as well as dolphins. All these species have anti-predator strategies against killer whales. Off Península Valdés right whales rush into shallow water near shore when attacked, to protect their undersides.

Two of those whales (right), a calf and mother, background, sense no threat approaching diver Michael Bennett.

As exuberant a whale as the sea could hold, a young humpback breaches in Alaska waters. In my cabin on Vancouver Island, I look over part of a photographic file that I have helped collect of humpbacks, the basis of most of the research on this species today. Thousands have been identified in the Atlantic and Pacific Oceans by the distinctive black and white markings on the undersides of their tails, a technique described by Steve Katona and his colleagues in 1979.

Working for the Paynes in Hawaiian waters in the late 1970s, I became intrigued with the humpbacks' songs, the repeated sequences of sounds sung by humpbacks in a given area that gradually evolve into new songs. I found I could locate singers, lone adults that usually hang motionless 50 to 100 feet below the surface, head down, sounding like a stereo at maximum volume.

To better understand their behavior, we sought to determine their sex. Flip Nicklin found a way. He learned to dive beneath the singers to photograph their genital slits (right)—in every case a male—and he had to hold his breath, since bubbles rising to that sensitive area could create a very skittish whale.

Thus learning the players, I saw two different patterns emerge when the males sang. Either a courting group passed by and the singer rushed to join it, or a lone male joined the singer and they quickly separated, sometimes after a scuffle. My interpretation was inspired by a photograph of a bighorn sheep that I was examining one day. I think the humpback song, much like antlers or horns of hoofed animals, could be a secondary sexual characteristic of males to display dominance. Visual displays would be less effective in an aquatic environment than an acoustic equivalent. Not all my colleagues agree, of course, but the investigation continues.

"GENTLE GIANTS" becomes a misnomer when violence erupts among humpback males competing for females during winter calving and mating in Hawaiian waters. As a group of males at the surface pursue a cow, one agitated suitor lashes his tail in a furious display (left). Another distends his throat pouch (above), perhaps to appear more formidable, and lunges toward a male in front of him. I have often watched pairs of humpbacks lashing each other with their tails, really beating the tar out of each other. Males use a variety of displays to gain dominance, including blowing a long string of bubbles, perhaps as a screen or warning to rivals.

It took many years to understand such behavior. Most cows with calves are accompanied by another adult, which scientists had long assumed to be a female "aunt" that helped the mother raise her calf. Then researcher Debbie Glockner-Ferrari began identifying the sex of the escorts and found they were all males, primarily interested not in baby-sitting the calf but in mating with the female.

This system of a dominance ranking among males that compete for females probably also applies to narwhals, toothed whales with an obvious secondary sexual characteristic, the tusk of the males, as long as ten feet. According to biologist John Ford, the males often travel separately from the cows and calves during the summer Arctic migration as the ice breaks up. "The males often joust with their tusks (opposite, above), tapping them together in a ritualized manner," he says. Scarring frequently seen on the heads of males suggests that the tusk also serves as a weapon. John believes that the calls narwhals produce represent a form of social language, and that the males probably have their own "signature" calls to identify themselves to other males.

WINDOWS into the most intimate corners of whales' lives have given us new insight into their courtship and mating strategies. In behavior seldom if ever witnessed (left), a male humpback at left appears to blow bubbles that will rise beneath the genitals of a female, center, accompanied by her calf. Is this a stimulation to mate? No one knows. Such gentleness contrasts with often fierce competition among males for a female.

Right whale males, however, show less aggression toward their rivals and sometimes even appear to cooperate in mating with the same female. Off Península Valdés (top) a male, at right, mates with a female as a second male waits his turn, left background. In another mating group a calf following its mother too closely is accidentally pounded by her massive flukes (right center)—a rare mishap since right whale females with calves usually avoid courting males. Its back also scuffed, another calf rests near its mother as she appears to mate (bottom).

Rather than by physical dominance, male right whales may pass on their genes by means of sperm competition. In theory, when numerous males mate with the same female, the male with the largest testes could displace or dilute the sperm of his rivals. And right whale males, with one-ton testes, have the highest testes-to-body-weight ratio of any baleen whale.

Right whale females calve only once every three years. In austral winter the tiny newborns keep in constant motion beside their mothers for their first month. A two- to three-month play stage follows; some exasperated mothers roll over and hold their young between their flippers to quiet them. In November mother and calf show signs of coordinated travel before departing for the open Atlantic . . . we know not where.

DAPPLED by Arctic sun, inquisitive belugas loll in Lancaster Sound. Each summer these white whales swim through open leads (below) into traditional bays and inlets. Studying the effects of shipping noise on belugas and other Arctic whales, Larry Dueck of Canada's Department of Fisheries and Oceans tape-records his observations; he keeps a shotgun handy against polar bears.

More than 10,000 belugas inhabit the Lancaster Sound region, although many more range above and below the Arctic Circle. Belugas' diet is as varied as their habitats and includes arctic cod, marine worms, bivalves, whelks, crustaceans, flatfish, salmon, char, and squid.

For their incredible voices, sailors called them "sea canaries." Their repertoire includes chirps, croaks, burps, grunts, squeaks, moos, mews, screams, and yaps, and has been likened to a horse's whinny, a baby's cry, a rusty hinge, a bell, and a lecher's whistle.

Belugas mate in spring, and after a gestation of about 14 months, most calves are born in summer. The warmer water may make life easier for the brownish gray newborns, which are wrapped in only about an inch of fat in contrast to adults' average of six to eight inches, more than a third of their weight.

A separate population of about 450 belugas in the St. Lawrence estuary is in trouble, with whales dying of cancer and other diseases that may be caused by pollution. Canadian researcher Pierre Béland and veterinary pathologist Daniel Martineau examined stranded belugas and found a horrible array of bladder cancer, ulcers, tumors, and high levels of toxic chemicals such as PCBs and DDT. Regional industrial and agricultural practices are suspected, but the situation remains unresolved.

DELPHINAPTERUS LEUCAS, 11 TO 18 FT., 1,900 TO 3,500 LBS.

In the soft wilderness of sea ice, snow-white belugas cruise Lancaster Sound with a bowhead, its breath lingering in the damp air. Christopher Clark and William Ellison, in

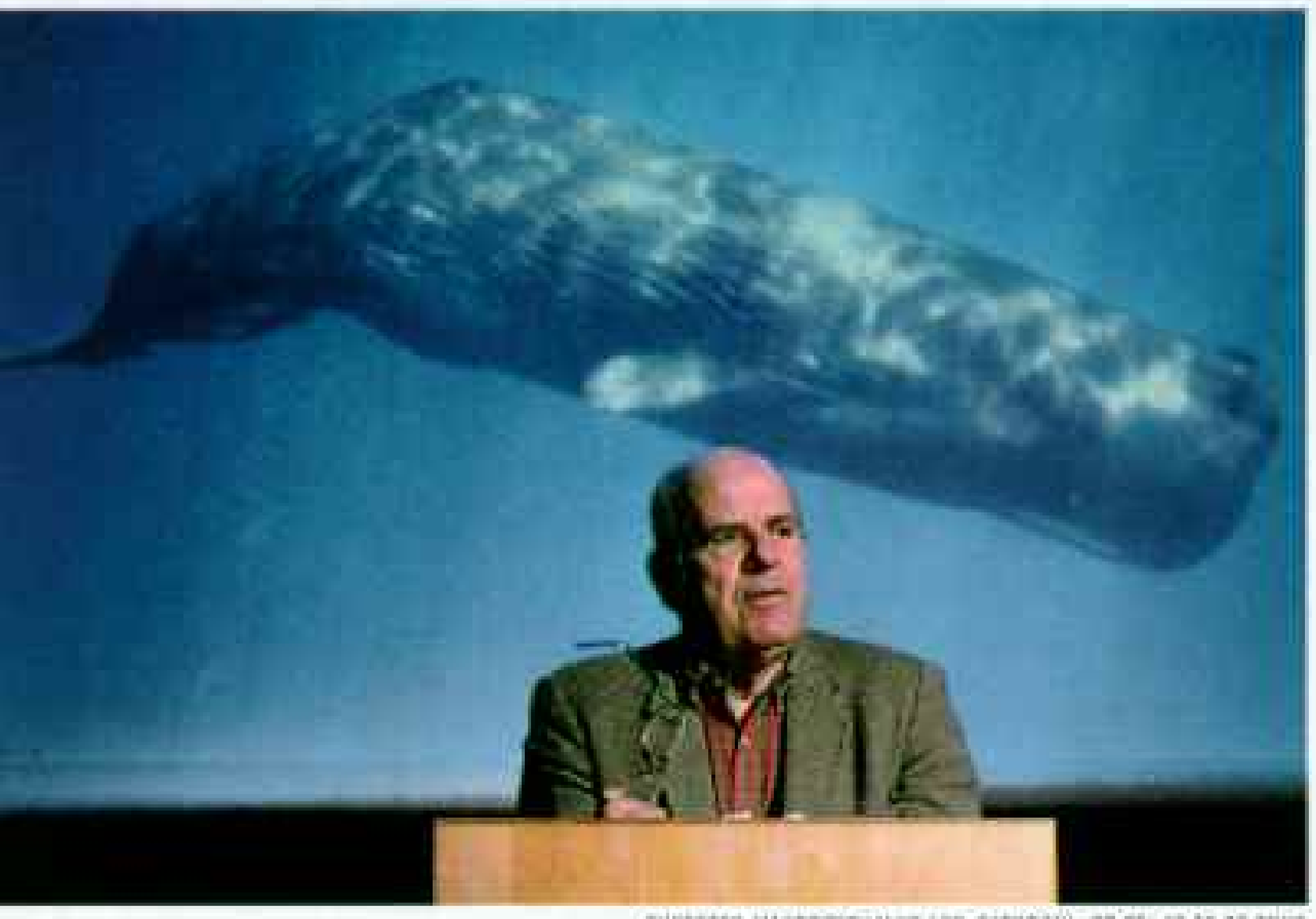
BOWHEAD, BALAENA MYSTICETUS, 50 FT, 50 TO 65 TONS

studying the sounds made by bowheads migrating through such vast stretches of broken ice, suggest that these animals follow an acoustic map in their heads.

LETHAL AS A HARPOON, a huge fishnet off Hawaii entraps a sperm whale, its fate unknown. The whale's echolocation system apparently was unable to detect the fine mesh. Nets hang like invisible fences in the ocean, perhaps 25 miles at a stretch, a grave threat to marine mammals.

Barbara Britten of the American Cetacean Society says that in the North Pacific alone 20,000 miles of drift nets are set each night and fatally ensnare about 10,000 Dall's porpoises, 50,000 fur seals, and at least 250,000 seabirds each year. In another of many conflicts between fishermen and whales, killer whales in Alaska have learned to pick off blackcod from longline hooks. Some fishermen retaliate with gunshots and powerful explosives.

Sperm whales may employ a special tactic when they hunt, a possibility that has long intrigued Kenneth Norris of the



PHYSETER MACROCEPHALUS (OR CATODON), 50 FT, 40 TO 50 TONS

The following GEOGRAPHIC *articles offer further information on whale topics:* "Gray Whales of San Ignacio," June 1987; "Narwhal: Unicorn of the Arctic Seas," March 1986; "Rare Look at Sperm and Blue Whales, the Unknown Giants," December 1984; "The Whales Called 'Killer,'" August 1984; "New Light on the Singing Whales," April 1982; "The Trouble With Dolphins," April 1979; "Humpbacks: The Gentle Whales" and "Their Mysterious Songs," January 1979; "The Imperiled Giants" and "Exploring the Lives of Whales," December 1976; and "At Home With Right Whales," March 1976.

University of California at Santa Cruz, here lecturing before a projected photograph of a sperm whale. Some of today's nearly 70 toothed whale species show an evolutionary trend toward fewer teeth. It is unlikely, for instance, that narwhal teeth function in feeding. To be sure, the sperm whale has teeth, but how much does it use them? Squid found in sperm whales' stomachs rarely bear teeth marks.

"It's a great mystery," says Ken, and it has led him and Bertel Møhl to propose their "big bang" theory. All toothed whales may have sophisticated sound-producing capabilities, including echolocating, or sonar, clicks to find and analyze food. The sperm whale's massive forehead, where those sounds are produced, is laced with a maze of channels filled with spermaceti oil. Ken thinks those internal structures might enable the whale to focus a powerful sound beam and actually stun its prey. His theory is not easy to test in the field, "and we haven't proven it," he emphasizes, but adds, "we have so many suggestive observations that we wonder if where there is smoke, there is fire."

Sperm whale acoustics have attracted many researchers, including Bill Watkins and Bill Schevill, who detected distinctive patterns of clicks called codas, which seem to be unique to individual whales. Hal Whitehead and Lindy Weilgart, who believe the codas may contain social information shared within a group, also witnessed how sperm whales deal with predators when killer whales attacked near the Galápagos Islands. The sperms formed a tight cluster with a calf in the middle, and the adults tried to keep their heads and jaws facing their attackers, successfully repelling them—behavior remarkably similar to one of the whale's even-toed ungulate relatives, the musk-ox.

Today we have come to demand more knowledge than the chilling information offered by sperm whales caught in drift nets or by pollution-poisoned belugas. "What now has to be sold in the most elegant fashion is that the future of whales and of life on earth depend on our stewardship of their ecosystem," says biologist Charles "Stormy" Mayo. "Now the critical battle begins, the battle to protect the ocean itself." □

GLOBE GORES

AZIMUTHAL EQUAL-AREA

BONNE

BRIESEMEISTER

AZIMUTHAL EQUIDISTANT

SINUSOIDAL

POLYCONIC

ROBINSON

OBLIQUE EQUIRECTANGULAR

INTERRUPTED GOODE HOMOLOSINE

AZIMUTHAL EQUAL-AREA

STEREOGRAPHIC

GNOMONIC (DODECAHEDRON)

VAN DER GRINTEN

New Perspective on the World

By JOHN B. GARVER, JR.
CHIEF CARTOGRAPHER

WITH THE MAP SUPPLEMENT in this issue, the Society passes another important milestone in its mapmaking history. For the first time since 1943 we are offering members a different and more realistic view of the world.

Globes, though often impractical and sometimes expensive, provide the only accurate portrayal of the world. However, we cannot see the whole earth at one time on globes, nor can we measure distances easily. Maps on flat paper provide a convenient solution, but all—including our old standby first published in 1922 on the Van der Grinten projection—distort the round earth in some way.

Our most recent search for a better way to "project" the globe onto a flat sheet began shortly after I arrived at the Society in 1982. Many new map projections have come along since 1922. The Society's 100th birthday gave the incentive to search for a new projection for our 1988 political map of the world.

In December 1987 a panel of cartographers was appointed to evaluate world map projections. After reviewing more than 20 projections, it was unanimously agreed that the one devised in 1963 by the eminent cartographer Arthur H. Robinson of the University of Wisconsin at Madison would serve us—and you—best. The staff and the Board of Trustees concurred.

Aside from the many merits of Robinson's projection, I was pleased with the decision for a personal reason. When I was a graduate student in the 1960s, Arthur Robinson had opened my eyes to the importance of map projections. Robinson conveyed an irrepressible enthusiasm for maps, and he still does. As he told me recently, "I've always studied map projections for serious reasons, and sometimes just for fun."

Recognized as the dean of American university cartographers, Robinson began his influential career during World War II, when he directed the Map Division in the Office of Strategic Services (OSS). His idea of a new projection for a world map sprang directly from work on a geography textbook in the late 1950s, but he says the seeds were sowed during the war. More often

NO FLAT MAP can render the round surface of the earth without distortion. But the Robinson projection (far left) comes relatively close; it was selected for the Society's new political map of the world.

SALUTING THE ACHIEVEMENT of his former teacher, Chief Cartographer John Garver gives a National Geographic centennial button to Arthur Robinson, who created his projection of the world in 1963. On behalf of the Society, Garver offered Robinson the title of "Honorary Chief," recognizing his lifelong dedication to cartography.

NGS PHOTOGRAPHER JOSEPH H. BAILEY

than not in those days, world maps were drawn on the Mercator projection, which Robinson admits having been "awfully sick of."

Years earlier, at the end of World War I, Editor Gilbert H. Grosvenor had also been irked by the Mercator. He called it "atrocious" for a world reference map. On November 14, 1918, only three days after the armistice with Germany was signed, he asked Chief Cartographer Albert H. Bumstead to produce a less distorted world map to show new boundaries and the new countries that would be born after the war. The result four years later was based on a projection patented in 1904 by Alphons van der Grinten of Chicago. Since then ten of the Society's 13 world political maps have used the Van der Grinten projection.

HOW TO STRETCH the round earth onto flat paper has challenged mapmakers for centuries. More than a hundred world map projections have been invented for drawing a spherical network of coordinates and points on a piece of flat paper (a selection of 18 are shown on the previous pages). Map projections come in almost every imaginable shape, including a rectangle, circle, ellipse, star, heart—even the form of a butterfly. Each projection has distinct characteristics, and many provide different, sometimes bizarre, views of the world.

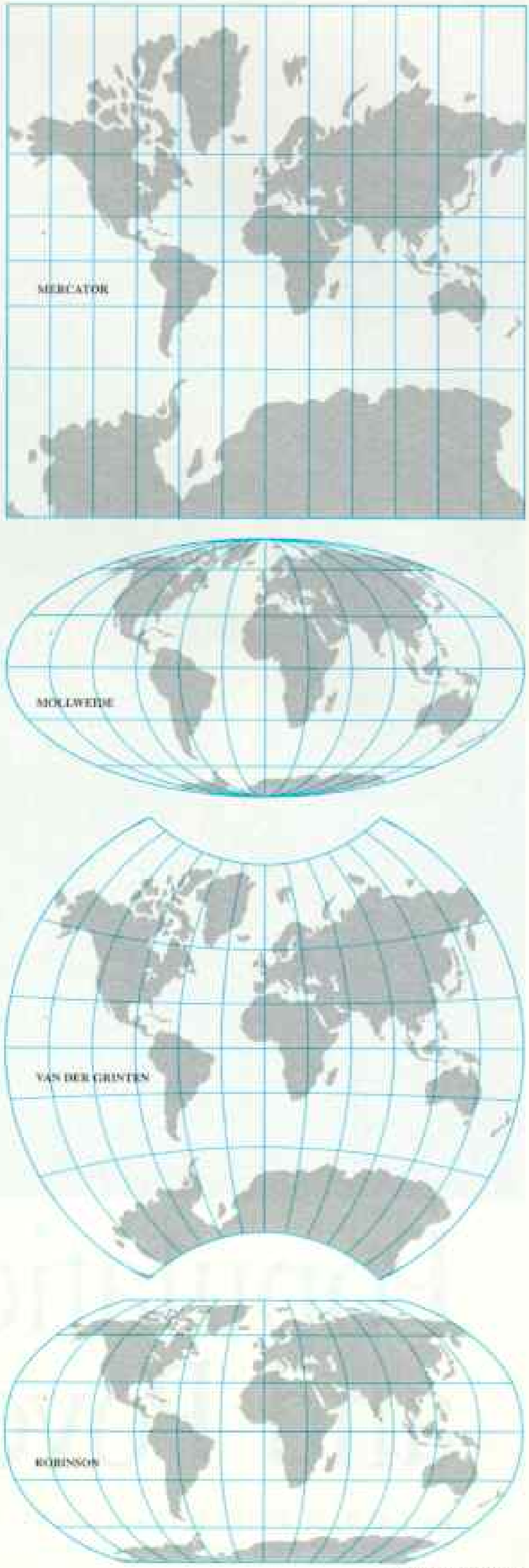
All projections cause distortion, because the skin of a round ball simply will not lie flat. All deform the shapes of continents; some projections enlarge or shrink them. Some interrupt the oceans, slicing them into unrecognizable patterns in an effort to map the landmasses better. All skew distances or directions between places. In choosing a world map projection there is no single solution; it is simply a matter of finding one that best suits the purpose of the map.

Such an approach led the Flemish geographer Gerardus Mercator in 1569 to introduce a projection geared to navigation on the high seas during the great period of world exploration. Any straight line on Mercator's map of the world is a line of constant true bearing, enabling mariners to plot a straight-line course between any two points. A boon to navigators, the Mercator is unacceptable for a world reference map, as Editor Grosvenor made plain years ago. The projection distorts large shapes and greatly exaggerates the size of landmasses in the high latitudes. Greenland, for example, appears much larger than South America, although in fact it is only about an eighth the size—roughly as large as Mexico. Alaska and Brazil look equal, but in reality Brazil is nearly six times the size of Alaska.

At the other extreme are equal-area map projections, such as the one produced by the German mathematician Karl B. Mollweide in 1805. These projections depict all regions of the earth in correct relative size. They are useful in displaying and comparing certain kinds of information, such as the distribution of populations or religions, especially in the temperate and equatorial latitudes. But most uninterrupted equal-area maps compress, elongate, or warp lands in the higher latitudes and cause shearing and stretching along the outer meridians. For this reason an equal-area projection such as the elliptical Mollweide is not the best for a reference map of the entire world.

For its world maps the Society has always preferred an uninterrupted projection that displays features on the earth and their relationships to one another as accurately and with as little distortion as possible.

THOUGH PRACTICAL for navigation, Gerardus Mercator's 1569 projection nevertheless distorted the relative sizes and shapes of landmasses when used for a map of the entire world. Karl B. Mollweide's 1805 equal-area projection also distorted shapes, but accurately represented relative sizes. Alphons van der Grinten's 1904 map, like Robinson's, is a compromise approach to minimize distortion of both size and shape.



The trusty Van der Grinten projection was chosen as a good compromise. In the high latitudes it avoids the extreme exaggeration of area of the Mercator and the extreme compressing and shearing of the Mollweide.

Arthur Robinson's projection is better still. In the combination of shape and area it matches reality more closely than its venerable predecessor. Whereas the Van der Grinten shows the Soviet Union and Canada at more than twice their relative size, the Robinson reduces the discrepancy to one and a half times. And although Greenland appears somewhat compressed on the Robinson, the exaggeration is considerably less. The projection does not espouse any special point of view, and we believe that its compromises are the most reasonable for a general reference map of the world.

MAPPING THE CONTINENTS, countries, oceans, and rivers presents a continuing challenge. Just as important is knowing where places are in the world and understanding their relationship to one another. As the National Geographic Society celebrates its centennial and prepares to move into the 21st century, President Gilbert M. Grosvenor is committing substantial resources to help restore geography education to United States classrooms. Maps and globes are crucial to this effort.

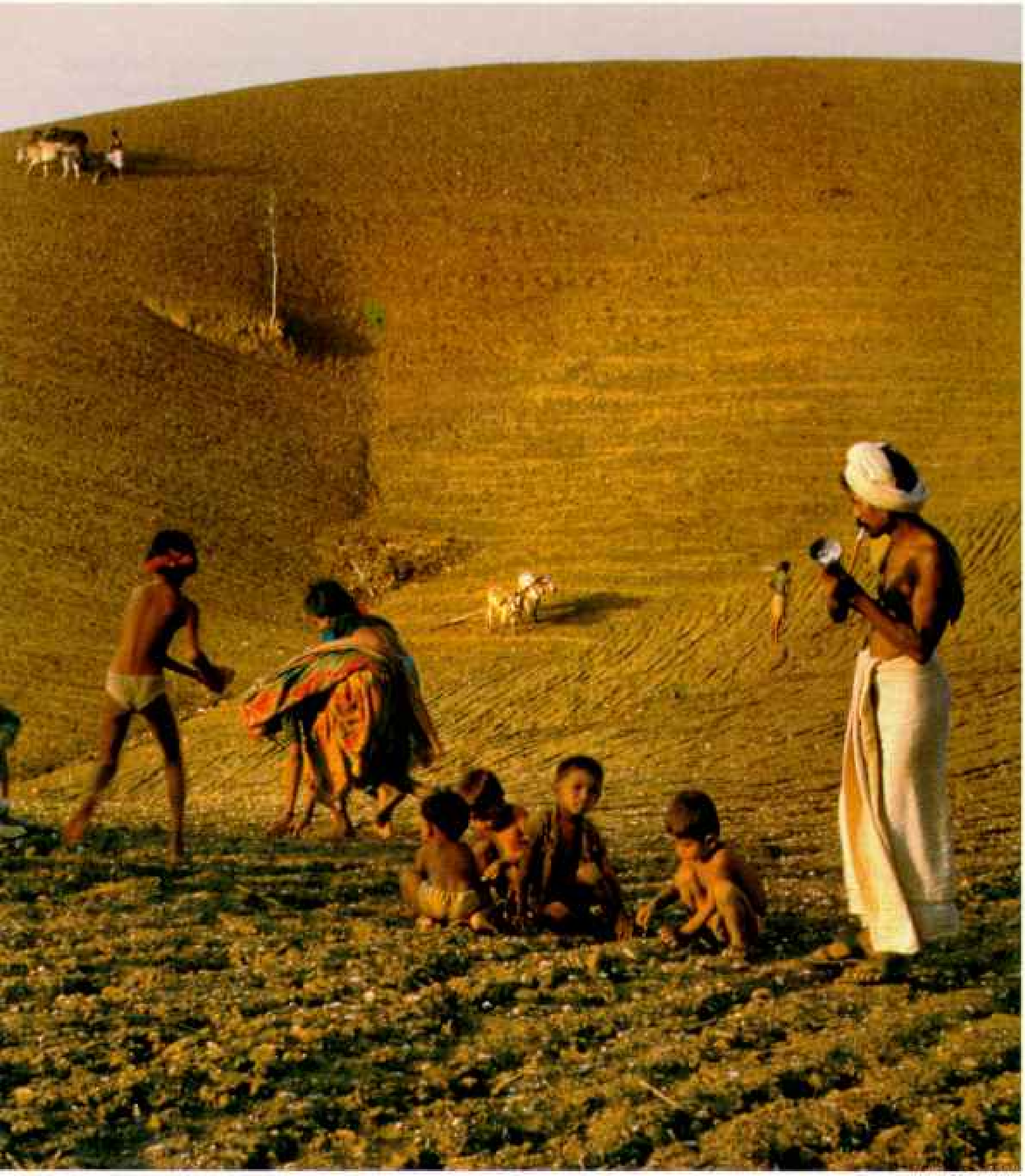
The new world map, used in conjunction with the Society's education programs, will, we believe, serve as a valuable resource for members, teachers, and students alike. Arthur Robinson's projection strongly suggests the roundness of the earth. We hope that its main legacy will be a generation of map readers more critical of flat maps—all of which play tricks with the round shape of the world we inhabit. □

New Perspective on the World

NGS CARTOGRAPHIC DIVISION

Population, Plenty, and Poverty

By PAUL R. EHRLICH and ANNE H. EHRLICH
DEPARTMENT OF BIOLOGICAL SCIENCES, STANFORD UNIVERSITY



RAGHU RAI, MAGNUM

One of ten sons whose 40-acre patrimony was divided ten ways, Ranchod Patel, at left, supports a family of seven on his small farm in India, where the population has more than tripled in the 20th century and could double again in 35 years. A rampant species, Homo sapiens *may be nearing full occupancy of earth's arable lands. Too many people along with disproportionate consumption by developed nations pose the dilemma of the next century, explored in the profiles of six families that follow.*

EARTH '88

"While overpopulation in poor nations tends to keep them poverty-stricken, overpopulation in rich nations tends to undermine the life-support capacity of the entire planet."

–PAUL R. EHRLICH,
Bing Professor of Population Studies, Stanford University

WHEN the National Geographic Society was founded in 1888, a billion and a half people inhabited the earth. Now the population exceeds five billion and is growing fast—by some 90 million in 1988. In essence the world must accommodate a new population roughly equivalent to that of the United States and Canada *every three years*. Even though the rate of growth has begun to decline, most demographers believe population size will still pass eight billion during the next 50 years.

In a sense today's five billion people represent a triumph of our species. By all measures we have become the dominant animal on the planet. Through a series of technological innovations that include farming, sanitation, and the control of many epidemic diseases, we have found ways to reduce the rate at which we die, creating a population explosion. Biologically this is the very definition of success.

But there is a dark side to our triumph. We live on a finite planet, and yet we act as if its resources were infinite. Because of overpopulation and overconsumption, humanity is incapable of supporting itself on its "income," the energy arriving continuously from the sun. Instead *Homo sapiens* is consuming its "capital," a onetime bonanza of nonrenewable fossil fuels and other mineral resources that formed over eons and are now being destroyed and dispersed in decades. We are doing the same with vital resources not usually thought of as being nonrenewable: deep, fertile agricultural soils, groundwater, and biodiversity—the untold millions of other species that share earth with us.

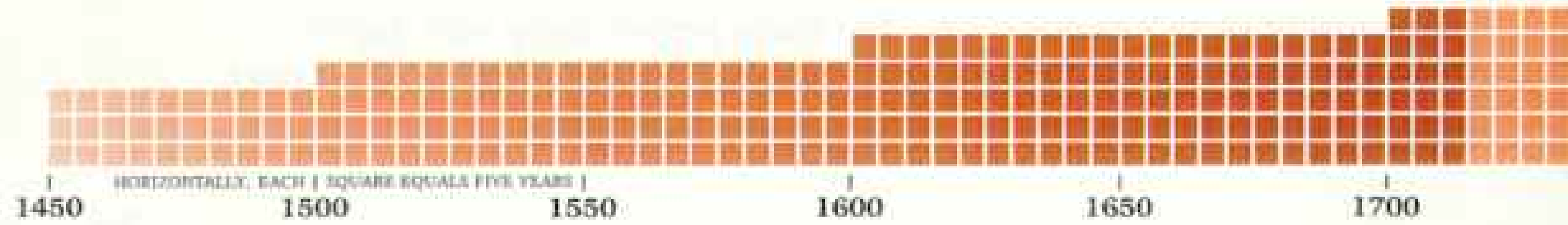
The mechanisms that supply us with income are ecosystems—plants, animals, and microorganisms interacting with each other and their physical environments. The energy that flows through these ecosystems and the oxygen, nitrogen, carbon, and other materials they recycle are the essence of the life-support system within which five billion people are inextricably embedded.

Ecosystems supply civilization with public services both free and irreplaceable. They include regulation of climate and the makeup of the atmosphere, generation and maintenance of soils, control of potential crop pests and carriers of human diseases, pollination of many crops, and provision of food from the sea. Ecosystems supply the nutrients without which we could not survive, and in the process they dispose of our wastes.

The vast array of organisms that ecosystems support can be thought of as a giant genetic library. Humanity has already withdrawn from that library the very basis of its civilization in the form of crops, domestic animals, industrial materials, and medicines. And its potential has barely been scratched. Understanding ecosystems and how civilization is living on

From the time of Christ it took some 1,700 years for earth's population to double, experts believe. Since then, human numbers have doubled three times (shading), in successively shorter spans. Projections now indicate the population will reach ten billion by 2070, doubling in just 82 years.

FIGURES PROVIDED BY THE POPULATION REFERENCE BUREAU; GRAPHICS BY DALE D. GLASGOW



capital provides the appropriate context for analyzing the population problem. It immediately exposes the myth that the impact of the population explosion stems primarily from poor people in poor countries who do not know enough to limit their reproduction. Numbers per se are not the measure of overpopulation; instead it is the *impact* of people on ecosystems and nonrenewable resources. While developing countries severely tax their environments, clearly the populations of rich countries leave a vastly disproportionate mark on the planet.

The birth of a baby in the United States imposes more than a hundred times the stress on the world's resources and environment as a birth in, say, Bangladesh. Babies from Bangladesh do not grow up to own automobiles and air conditioners or to eat grain-fed beef. Their life-styles do not require huge quantities of minerals and energy, nor do their activities seriously undermine the life-support capability of the entire planet.

For example, tropical forests are known to be the major reservoirs of biodiversity of species that can supply humanity with many direct benefits and are working parts of ecosystems. The clearing of tropical forests is usually an attempt (often unsuccessful) to provide farms for rapidly growing populations of poor people. But it also results from the *affluence* of people in rich countries. Central American forests are destroyed in part for pastureland to make pet food and convenience food in the United States slightly cheaper; in Papua New Guinea forests are destroyed to supply cardboard packaging for Japanese electronic products. Thus a rich person thousands of miles away may cause more tropical forest destruction than a poor person living within the forest itself.

The connection of population growth in wealthy nations to global environmental problems can most readily be seen in the rise in atmospheric levels of the gases carbon dioxide and methane. These "greenhouse" gases trap heat near earth's surface and thus alter the climate. Major sources of increased CO_2 are the burning of fossil fuels—clearly related to affluence—and the destruction of forests. Major sources of methane include not only intensive wetland cultivation of rice but also large populations of cattle, whose digestive tracts give off methane at both ends.

In short, while rapid population growth in poor countries impedes the escape from poverty and often leads to local environmental deterioration, overpopulation and resource consumption in rich nations threatens earth's capacity to sustain us all.

The following pages illustrate the life-styles of families in six nations, rich and poor, and how they impact the global environment. * * *

A Population Exploding

Photographs by ROBERT CAPUTO

KENYA'S GROWTH RATE hovers around 4 percent a year, highest in the world; its population will double in about 17 years to 46 million. Though predominantly agrarian, Kenya has not been blessed with much rich arable land. It also has suffered from the recurrent droughts that have afflicted all of Africa along the southern edge of the Sahara since the late 1960s. Food production has fallen far behind population growth, and economic growth has lagged—problems reflected in the constrained lives of Njoroge and Susan Munoru and their children.

Doubling time of population in years at current rates:

KENYA	17
BRAZIL	34
INDIA	35
CHINA	49
U.S.A.	100
HUNGARY	never

Kenya's rapid population growth has translated into intense pressure on the nation's limited farmland. Often a husband finds that the family farm cannot support a large and growing family, and he may migrate to Nairobi or the nearest town in search of work, leaving his wife to run the farm and raise the children. Women have very low status and little or no education in most African nations, yet they have the primary responsibility for food production and child rearing.

By tradition a farmer's land is divided among his sons when he dies. Since subdivision can only proceed so far before farming becomes uneconomical, many young men seek land or a living elsewhere—often by poaching or encroaching on national parks. Thus Kenya finds that the efforts of its impoverished people to stay alive threaten its main source of foreign exchange: tourism centered on game parks. Without the foreign exchange from tourism, it is difficult to imagine how Kenya can survive the many decades it will take to bring its population growth under control and strengthen its agricultural sector—a serious problem that the Kenya government is acutely aware of.

Because of its unique parks, Kenya is one of the few places left where people today can see what it must have been like for our Ice Age ancestors to live in a world populated by huge herds of large mammals. As such it should be a concern of all nations that Kenyans be in an economic position to preserve that bit of the heritage of *Homo sapiens*.

In the world's fastest growing country, Njoroge and Susan Munoru raise four children on a pittance of land: one of six adjoining half-acre strips (right) passed on to Njoroge and his five brothers at the death of their father. Unlike his brothers, whose plots often lie fallow, Njoroge actively tends to his land, growing coffee trees for cash to educate his children.

Photojournalist ROBERT CAPUTO writes and photographs frequently for NATIONAL GEOGRAPHIC. He lives in Washington, D. C.

The Munorus

MEMBERS OF THE KIKUYU, Kenya's most westernized tribe, Njoroge and Susan Munoru have a dream: to see their four children through secondary school. A modest goal in many countries, it will require great sacrifices from the Munorus, whose coffee crop last year earned them only $120 after expenses for fertilizers and pesticides. The primary school, where seven-year-old Julius and his classmates assemble each morning for flag raising (left), charges $75 a year. Next year the bill will double when Julius's five-year-old sister, Njeri, enters first grade. Three years later, when the twins, Nganga and Beati (a boy and girl), come of age, the fees will double again. To boost his income, Njoroge has increased his coffee plantings from 120 to 250 trees. While there will still be marginal grass to support his one cow, there will be less space for food crops, such as corn and potatoes.

Like many of Kenya's small landholders, Njoroge, a trained stonemason, supplements his income with day work in nearby towns, where he earns about five dollars a day. When work is available, Susan earns about two dollars a day in the fields of larger farms. But even with their extra income, they barely can afford the necessities of life. Meat is a luxury rarely enjoyed.

For Susan life is an endless round of long, burdensome treks. Charcoal for cooking must be hauled (top) from a kilometer away. For food staples she walks four kilometers to the market town of Githumu (above), returning by bus when she can afford it. Even water must be carried from a distant stream. But during the rainy season, runoff is collected from the roof of their small mud and wattle house, where Njeri gets a shampoo and hair treatment from her cousin Mary (above left).

Reflecting a new attitude in Kenya, the Munorus do not want more children. "If we have more, how can we send them to school, how can we feed them?" asks Susan. In a major change of policy, Kenya's leaders now talk of the need for family planning.

Back from the Brink

Photographs by PATRICK ZACHMANN MAGNUM

CHINA's population, the largest in the world at 1.1 billion, represents some 21 percent of the total human species. Until a decade or so ago it also was among the faster growing populations. But thanks to a remarkably vigorous and effective national family-planning program, coupled with equally effective health and educational programs, China's population growth rate has been cut in half even as mortality rates continue to fall.

By 1970 China's leaders realized that rapid population growth was hindering economic development. A rough estimate of the country's natural resource base indicated that the maximum desirable population in the long term was about 700 million.

As the population neared a billion in 1979, the government launched its famous "one-child family" program, offering incentives to couples (already encouraged to have a maximum of two children) to pledge themselves to only one. The goal was not only to end growth but also to reduce the population to an optimal level—the first nation to attempt this.

The program, though successful by world standards, has encountered opposition. The traditional preference for sons has led to extra births and a resurgence of female infanticide. There is concern that a generation composed largely of single children would be faced with supporting a much larger generation of elderly parents. And a new policy allowing families to earn private income, while spectacularly successful in increasing food production, unexpectedly created an incentive to have more children to help earn the income. The result has been a recent surge in the birthrate and new efforts to impose acceptable restraints.

China's high per capita energy use partly reflects a widespread use of coal at the household level (in addition to locally cut fuelwood as in most poor countries) and inefficient combustion. This has shown up in severe air pollution and acidic rainfalls. If energy use in China, with its large reserves of coal, ever reaches a level comparable to that in developed nations, the atmospheric consequences would be catastrophic. One of our most serious dilemmas is to find ways for poor countries to develop without making the earth uninhabitable.

China has emerged as a leader in a grand experiment in the management of population and natural resources. In this crowded, resource-depleted land, the future of more than a fifth of the world's population hangs on decisions being made today.

Paris native PATRICK ZACHMANN's photographs have been widely published in Europe and the U. S. In 1987 he won France's Medicis Prize.

Average annual growth rate of gross domestic product 1980-86:

CHINA	10.5%
INDIA	4.9%
KENYA	3.4%
U.S.A.	3.1%
BRAZIL	2.7%
HUNGARY	1.6%

Object of adoration for his parents and grandparents alike, young Yu Kuo will attend school this year with an emerging generation of "little emperors," as China's new crop of only children are affectionately known. Growing rabbits for food (left) and rapeseed (below) for a cash crop, the Kuo family epitomizes China's new breed of prosperous peasants. Only through stringent family-planning policies, say China's leaders, can the nation sustain its economic revival.

The Kuos

LIVING IN A TOWN FULL of relatives, Koping Kuo and his wife, Chao I Ping, often find the courtyard of their home (above) bustling with communal activity such as shared laundry chores. Following tradition, Chao I Ping moved in with Koping and his parents, Dai Hong and Ah Mai, when they were married. On four hectares (ten acres) in the fertile delta of the Yangtze, or Chang Jiang, the Kuos cultivate cotton, rice, wheat, and corn (left), which they sell to a state cooperative for an annual income of about $700. Though they could earn more by growing produce for a cash crop, they have been encouraged by the government to concentrate on food grains for the benefit of the nation. Thus Ah Mai (above right) needs to buy many of their foods in the village market of Chiu Chin. Though poor by Western standards, the Kuos enjoy a relatively comfortable life. Meals (below) usually include rice, fish soup, and homegrown vegetables. Slowly the amenities of modern life are appearing in their household, including a washing machine and a television set. Electricity, however, is not available during the day, when the energy demand of the province's growing number of rural industries takes priority.

Life is comfortable for Nándor Budai and his family in a Budapest suburb, where he and his wife, Ilona, relax with their children in front of their four-room house. In their basement the Budais earn about $5,000 a year making machine parts for a state cooperative.

Like much of Europe, Hungary's birthrate has declined to zero growth. The government is concerned and hopes to reverse the trend. But rising expectations bode increased resource consumption.

A Static Society

Photographs by STEVE McCURRY MAGNUM

Projected annual growth rate of labor force 1985-2000:

HUNGARY	0.3%
U.S.A.	0.8%
CHINA	1.4%
INDIA	1.8%
BRAZIL	2.1%
KENYA	3.7%

BIRTHRATES have been low for many decades in this Eastern European, Communist nation. Today the average Hungarian family—the Budais are typical—has fewer than two children, and the population has stopped growing and begun a very slow decline. The government is actively trying (with little success) to encourage its people to have more children.

The attainment of zero, and even negative, population growth is so far an exclusively European phenomenon. The total population of Europe, east and west, is just shy of half a billion, and the annual rate of growth averaged over the region is only 0.3 percent. Among the nations, besides Hungary, that have stopped growing are both Germanys, Austria, Denmark, and Italy, while the United Kingdom, Sweden, Norway, Belgium, and Bulgaria are very close.

Unfortunately many political leaders are unaware of the advantages of nongrowth and are actively trying to reverse it. The disadvantages are easily perceived: an increased burden of elderly people to support, an aging work force, and slower economic growth. The advantages, though less obvious, are compelling: a stable work force, a smaller burden of children to support and educate (compensating the larger fraction of elderly), lower crime rates, less pressure on resources, less pollution and other environmental deterioration.

Hungary has shared in the economic stagnation seen throughout the Communist bloc in recent years, despite its role in the region as a pioneer in allowing some entrepreneurial activity. Its per capita energy use is about 40 percent that of the United States, and its income less than an eighth. (This figure may be somewhat misleading because prices and wages in Communist nations are closely controlled by the state.)

The stagnation stems partly from the fact that Hungary is among the world's least efficient nations in energy use; its policies actually encourage industry to waste energy. Like many other Eastern-bloc nations, including the Soviet Union, Hungary also has weak pollution-control policies. As a result it suffers severe water pollution and acid rain; a disproportionate amount of the energy used contributes to environmental deterioration rather than to the well-being of the people.

NATIONAL GEOGRAPHIC contract photographer STEVE MCCURRY, 1984 Magazine Photographer of the Year, makes his home in New York City.

The Budais

KEEPING UP WITH THE Joneses, Hungarian style, Nándor and Ilona Budai possess all the tokens of middle-class comfort: their own home, several appliances, attractive clothes—even a Soviet-made car for picnics in the country (top left). Like that of most Hungarians, however, theirs is a lean prosperity, earned through sacrifice and moonlighting in the "underground economy" found in Eastern-bloc nations. Besides helping her husband in his machine shop, for example, Ilona works part-time making venetian blinds for another company.

The boldest economic reformers in Eastern Europe, Hungarians

saw their standard of living rise dramatically during the 1970s. Today, in her supermarket (below), Mrs. Budai finds an abundance and variety of food not seen in most Communist nations. Now heavily in debt, however, the Hungarian government is attempting to curb consumerism and has introduced something unheard of in Communist countries: a personal income tax.

For Nándor prime time is a soothing soak in one of the many thermal baths of Budapest (far left), a popular diversion since the days of the Romans. Avid windsurfers, the Budai children also share a taste for American pop music, which 17-year-old Monika listens to with headphones while jogging. Though she prefers jeans, Monika wears a miniskirt when shopping with her mother in downtown Budapest (above), which in recent years has become a shopping center for bargain-hunting foreigners.

Far from their school in Budapest, the Budai children spend two hours a day commuting by bus and subway. Career oriented, both are diligent students. Nándi, 14, hopes to become an electrical engineer, while Monika wants to become an artist.

Life on the Edge

Photographs by RAGHU RAI MAGNUM

A NATION OF CONTRASTS, India contains both a developed industrial structure and an impoverished majority living traditional lives, seemingly untouched by the 20th century. Its population is the world's second largest (after China's) and still increasing by 2 percent a year, despite an active family-planning program since the 1950s.

India refers to itself as the world's largest democracy, and to a large degree that is true. This, plus the nation's cultural diversity and remnant caste system, may explain why family planning has been less successful than in China, where the centralized government has more power to enforce its policies. India's efforts also have been hampered by such factors as high rates of illiteracy and infant mortality, low status of women, conflict between castes and religious groups, inconsistent government policy, poor internal communications, and, of course, poverty.

India's performance in feeding its 800 million people has been considerably better. In the late 1960s, when monsoon failures were wreaking havoc with food production, India became a pioneer in the green revolution through the introduction of high-yield wheat supported by extensive irrigation and a growing fertilizer industry. The nation became a green revolution showcase self-sufficient in food in most years, largely because of successful increases in the wheat harvest.

Yield increases in corn and rice, however, were much more modest, and crops such as lentils and other legumes (important in a society with vegetarian habits or people too poor to buy animal protein) were neglected as wheat acreage expanded. People in some regions flourished, others were perhaps worse off.

Potential additional increases from green revolution technologies are limited, and India's population has grown by several hundred million since they were introduced. Monsoon failures in the 1980s have once again brought food shortages. Today India has no margin of safety in the struggle to feed a population steadily climbing toward a billion.

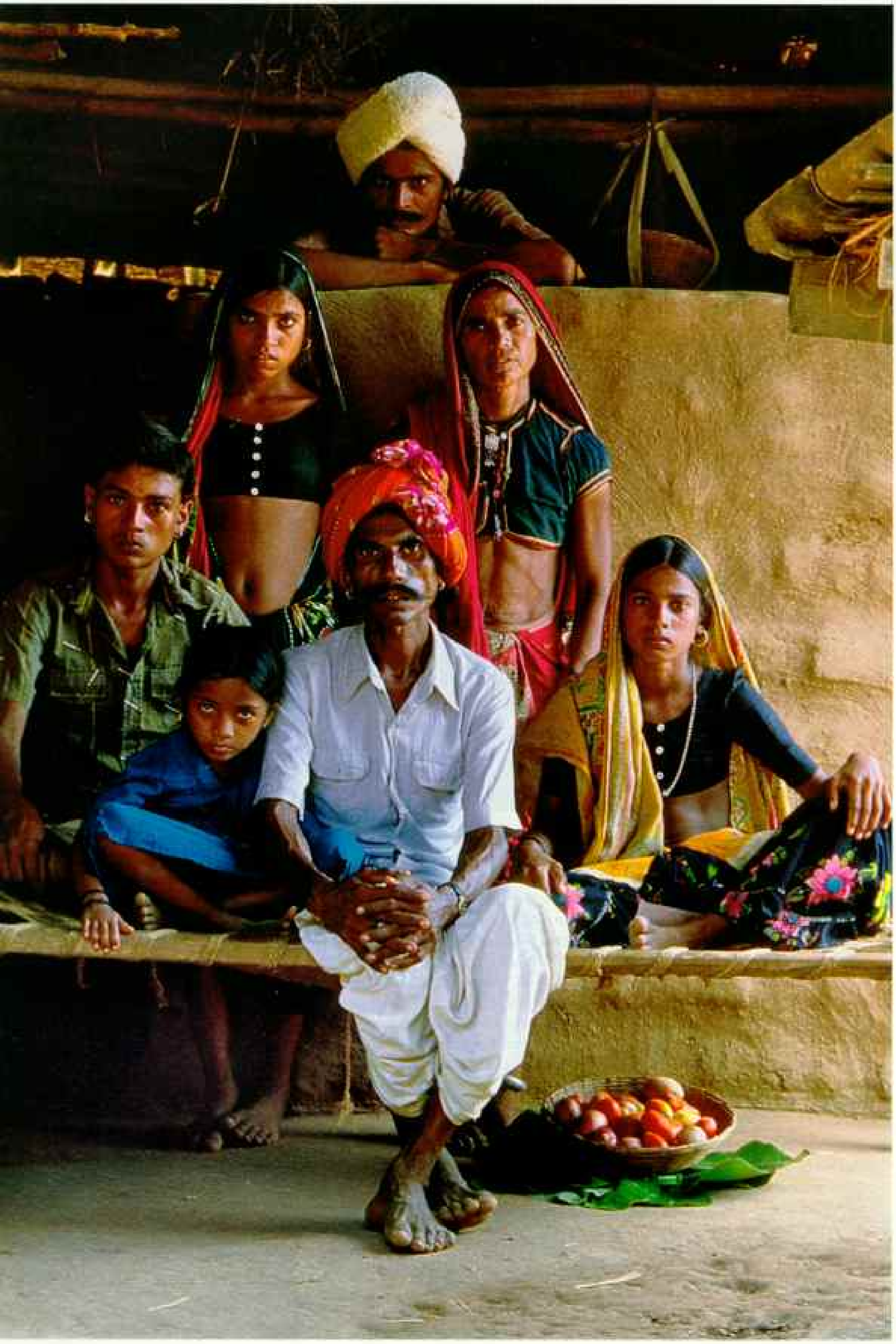
RAGHU RAI was born in the Punjab in 1942. His photographs are regularly published in major magazines and newspapers around the world.

Infant mortality per thousand live births:

INDIA	104
KENYA	76
BRAZIL	63
CHINA	44
HUNGARY	19
U.S.A.	10

Remote from 20th-century life, Ranchod Patel and his family live in one of India's more than half million rural villages. Between monsoons they haul their water from a distant well across the parched hills of Gujarat state.

Choosing persuasion over coercion, the Indian government struggles mightily to curb a relentless population growth. Even so, India is growing by 16 million people a year and will reach one billion by the year 2000.



The Patels

LIFE-GIVING RAINS arrived on schedule in June, bringing joy and relief to Ranchod Patel (right), who surveys his cornfields—four acres of his own, and four leased—in the fertile hills of western India. In recent years the monsoons, key to existence for 70 percent of India's farmers, have been disappointing. When they are good, Ranchod earns about $700 a year, roughly the amount he spent on his oldest daughter's marriage. Never having lost a child or practiced birth control, Ranchod and his wife, Fundli, have six children, five still at home. Common to rural India, only the sons, Zam Singh and Ramish, can read and write, though the youngest daughter, Kavita (top center), hopes to break that tradition. Recently married, Zam Singh uses condoms, which he gets from a clinic.

With his six goats, four oxen, two cows, one buffalo, and electricity in his home, Ranchod is considered a wealthy man by village standards, a position affirmed by the murals in his home (top right), painted by itinerant artists. Nonetheless, life is hard for the Patels. During dry months, when fodder is scarce, they must strip their few trees of branches (above) to feed their animals. To supplement income between harvests, the sons and one daughter travel 85 miles to the city of Baroda to work as laborers.

Slum with a view, Santa Marta clings precariously to the heights above booming Rio de Janeiro (below), where Ana Carmo dos Santos, left, plays with a neighbor. One of 400 such shantytowns, the favela harbors thousands of rural migrants, like Ana's mother, Artera do Carmo (right), and family, drawn to the city by desperate hopes for a better life. Poor education is the curse of the favelas, where more than half the children never get past the second grade. Only 14 percent of all Brazilian children finish primary school.

Flight to the Cities

Photographs by MARY ELLEN MARK

Increase in urban population 1950-1988:

BRAZIL	34%–71%
HUNGARY	37%–58%
KENYA	6%–19%
U.S.A.	64%–74%
CHINA	11%–21%
INDIA	17%–25%

BRAZIL is often referred to as a middle-income country, with an average per capita income far below that of the rich countries of Europe and North America but well above the poorest levels exemplified by India and Kenya. Brazil is an outstanding example of a two-tiered society, one in which wealth is concentrated in the hands of a relatively small fraction of the population and in which the majority are poor, as represented here by the Dos Santos family. The nation also is economically divided between the largely impoverished tropical north and the temperate south, with its concentration of industry and wealth. Attracted by the prospect of jobs, migrants have flooded from the north and northeast into Rio de Janeiro and São Paulo and built shantytowns next to apartment towers and affluent suburbs—desperate poverty existing side by side with great wealth.

Overpopulation has contributed to economic inequity in Brazil by swelling the ranks of both unemployed and underemployed. Deforestation and desertification in the extremely poor northeast have helped drive environmental refugees not only to southern cities but also to development projects in the Amazon basin. Conversion of small farms in the south to industrialized agriculture for export crops has also displaced thousands of people from the land. In the Amazon region, the condition of the refugees is equally desperate (see article beginning on page 772 of this issue).

The potential for gaining a long-term sustainable return from the wealth of the Amazon is being mortgaged by the Brazilian policy of using the region as a safety valve for its exploding population, which is increasing by around 2 percent a year. With well over a third of its present population of 145 million people under the age of 15 and due to enter the labor force during the next 15 years, the nation faces even more fearsome employment problems.

In addition to population growth, Brazil faces a host of other problems: a social system that perpetuates economic inequity, racism as pervasive as that in the United States, ingrained sexism, and inept government coupled with extensive corruption (on which Brazil has no monopoly).

On the plus side, however, Brazilians are a vigorous and forward-looking people, possessed of a vast and resource-rich piece of real estate—priceless ingredients for solving their substantial problems of poverty and overpopulation.

New York-based MARY ELLEN MARK photographs for major publications worldwide. A recent GEOGRAPHIC credit, "Sydney's Changing Face," appeared in the February 1988 issue.

Artera and Edmar

ONE DAY AT A TIME: That is Artera do Carmo's approach to life. With her daughter Raimunda at her side, she nurses her two-year-old daughter, Eduarda (right): a common practice among mothers in the favela, where mother's milk is a vital nutrient for as long as it lasts. Migrants from Brazil's drought-plagued northeast, Artera and her common-law husband, Edmar dos Santos, are typical of the 11,000 people who live in Santa Marta. Having never practiced birth control, they have had seven children, one of whom died of pneumonia at five. A family produce stand, which earns them about four dollars a day, is their primary support. Though Artera sometimes splurges on junk food for her children, rice and black beans are their main diet.

While their father, who is an alcoholic, sleeps late, Raimunda, 10, and her brother Edson, 16, rise at 4 a.m. to pick through the discarded fruits and vegetables of a nearby market (below).

Salvageable items they take to Edmar's produce stand, before he arrives around 9 a.m. Angela, 17, supplements the family income by working as a nanny. Only she and her sister Ana, 12, can read or write. Edson and Raimunda, like their parents, are practically illiterate. Raimunda is still in the first grade, where she has trouble staying awake after her morning chores. Worse yet, her mother cannot afford the textbooks she needs.

Despite Edmar's drinking problem, he and Artera enjoy an affectionate relationship (left). Both look forward to their occasional nights out at neighborhood parties (right). The Roman Catholic Church figures strongly in the family's life, though Artera also follows the animist macumba cult. "It won't do me any harm," she says. "And you never know."

Geared to Consumption

Photographs by PAM SPAULDING

THE IMPACT of affluent nations on earth's resources is revealed by a look at the United States. This sketch of the Brogans of North Carolina shows how an average U. S. family affects the environment 40 times more than India's Patels or a hundred times more than Kenya's Munorus.

Conveniences taken for granted by the average American are impossibly beyond the reach of most Kenyan or Indian households—items such as cars, televisions, refrigerators, dishwashers, ranges, air conditioners, and numerous small appliances. The same applies to the dazzling variety of food found in ordinary American supermarkets.

Number of registered cars 1986:

U.S.A.	135,431,000
BRAZIL	10,827,000
HUNGARY	1,539,000
INDIA	1,414,000
CHINA	761,000
KENYA	126,000

The Brogans' vehicles, two of 180 million cars and trucks in this mobile society, illustrate the culture's demands on resources and environment.

The metals in the vehicles are nonrenewable resources won from their ores with much use of energy and a variety of environmental costs: air pollution emitted at mine and smelter and destruction of ecosystems at the mine site from building roads and dumping overburden.

A long list of side effects flows from a vehicle's use: the environmental costs of petroleum extraction, refining, and transport; the pollution and ecosystem destruction from building roads, bridges, parking garages, shopping centers, gas stations; and exhausts that contribute to eye irritation, emphysema, and lung cancer, as well as to acid rain and the greenhouse effect.

Because of the complexity of this web, we often fall back on a single measure of its impact: per capita energy consumption. It is by this standard that a U. S. family uses so much more of earth's resources than an average Indian or Kenyan family.

The U. S. population, like that of many other industrialized nations, is growing slowly: about one percent a year—0.7 percent through natural increase (the gap between birth and death rates), the rest by immigration. Without immigration the U. S. population could stop growing within a few decades, joining the half dozen European nations whose population growth has stopped or is even declining.

All-American family, the Brogan household of Durham, North Carolina, exemplifies the mobile lifestyle that has made the United States one of the world's highest per capita consumers of energy. Though prudent users of energy at home (above), the Brogans spend about 18 weekends a year on the road. Here the children indulge in an American invention—fast food—during a trip to the mountains in a church van.

A 1985 Nieman Fellow, PAM SPAULDING lives in Kentucky, where she photographs for the Louisville *Courier-Journal*.

The Brogans

IN HER SUGAR-AND-SPICE bedroom, Melody Brogan (left), 9, picks out clothes for one of her family's monthly 85-mile drives to Martinsville, Virginia, where her parents, Arnold and Patricia (Arnie and Trish), were born and raised. While there, her grandmother Goldie Brogan (below) helps her dress for a family wedding, some 50 miles farther away in Roanoke.

In their van—one of two family vehicles—the Brogans also take six weekend vacations a year to the far ends of their state: their alternative to an extended holiday. Their favorite getaways are a church camp in the mountains of western North Carolina and Surf City, a beach resort 175 miles southeast of Durham. There they stay in a beach home (bottom left) rent free in exchange for maintenance that Arnie performs for the owner.

Economies like this are important to the Brogans, who wage constant battle with their sons, Matt, 13, and Mark, 11, over expensive clothes. Trish, who works as a mortgage loan processor, helps stretch the family budget by cutting everyone's hair.

A former carpenter, Arnie recently started work as a contract administrator for a development company. The Brogans center their lives around the Southern Baptist Church (left), where Arnie serves as a deacon and Trish teaches Sunday school. A quiet and devout man, Arnie rises at 5:30 on most mornings to read Christian literature and enjoy his "quiet time."

Two Ways to Cope

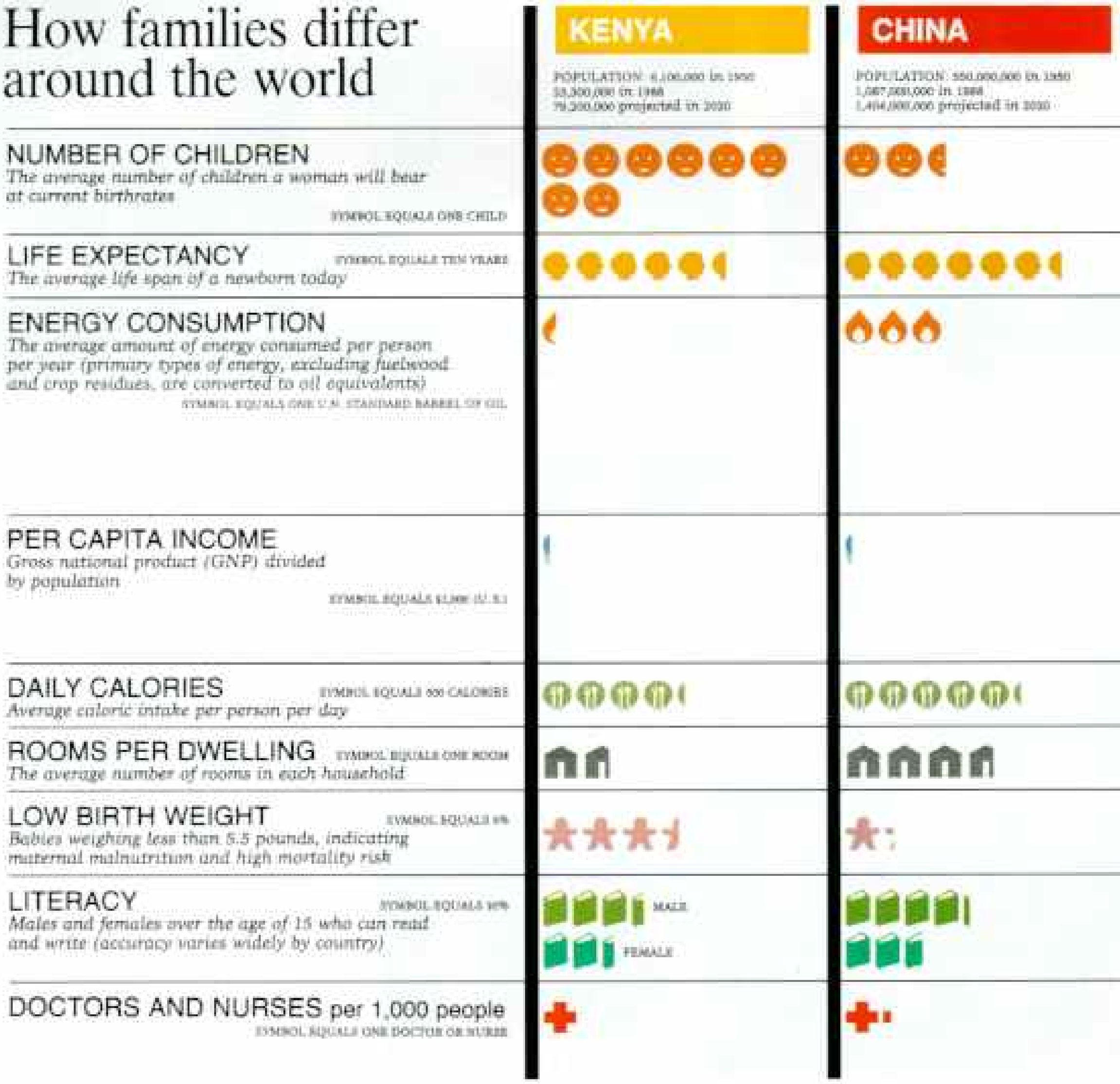
How can humanity deal with the problems of expanding population? Can we avoid the greatest threat of all? Human numbers may outstrip earth's ability to provide sufficient food and simultaneously impair that ability through environmental degradation.

The supply-side answer to food shortage is to grow more and distribute it equitably. But in many areas farmland is deteriorating under the pressure to maximize yields. Failure to husband soil properly has made erosion a global problem.

Moreover, many of the technologies that helped raise crop yields dramatically in the 1960s and 1970s have achieved most of their potential. Much more fertilizer is being applied to farmland than was used three decades ago. But fertilizer use provides a classic example of diminishing returns—at some point gains in productivity from additional use are so small that further applications are not worth the cost of the fertilizer.

The degree to which food production can be boosted by bringing more land under cultivation is also severely limited. People have

How families differ around the world



farmed the best land first. Most of what remains uncultivated or ungrazed is of poor quality: rocky, steep, infertile, too dry, too wet, or inaccessible. Furthermore, much "empty" land is actually providing civilization with crucial ecosystem services. This is particularly true for humid tropical areas such as the Amazon basin, which have important influences on the planet's climate.

The prospects of obtaining substantially more food from the oceans are also poor. Since the early 1970s, the world fish catch per person has been declining.

The most ominous threats to agriculture and natural ecosystems are human-induced changes in climate projected to result from additions to the atmosphere of trace gases that will bring on the greenhouse effect.

Extremes in weather usually result in crop losses—as last summer's drought and heat wave in the North American grain belt clearly demonstrated. While it cannot be demonstrated that the 1988 drought was caused by climate change induced by the greenhouse effect, scientists do point out that it was just the kind of unusual weather expected to become more frequent as the greenhouse gases build up.

Further, crop losses in North America's farm belt are a disaster for the world; the region is the chief supplier of a world grain market on which roughly a hundred other nations depend.

Yet, disheartening as the prospects may seem for feeding a population that grows by 90 million a year, there is no need for

SOURCES: POPULATION REFERENCE BUREAU, WORLD BANK, UNITED NATIONS
DESIGN: ALLEN CARROLL RESEARCH: JAN P. HAMBLING PRODUCTION: MEGHAN M. KOEPPER

despair. Human beings have created their dilemma, and they still have the opportunity and ability to solve it. Crop yields can still be increased in many regions. Surplus foodstuffs can be more effectively transferred to the hungry, soils can be saved, and the burning of fossil fuels can be made more efficient to slow the rate of release of greenhouse gases, buying time to make adjustments to climatic change.

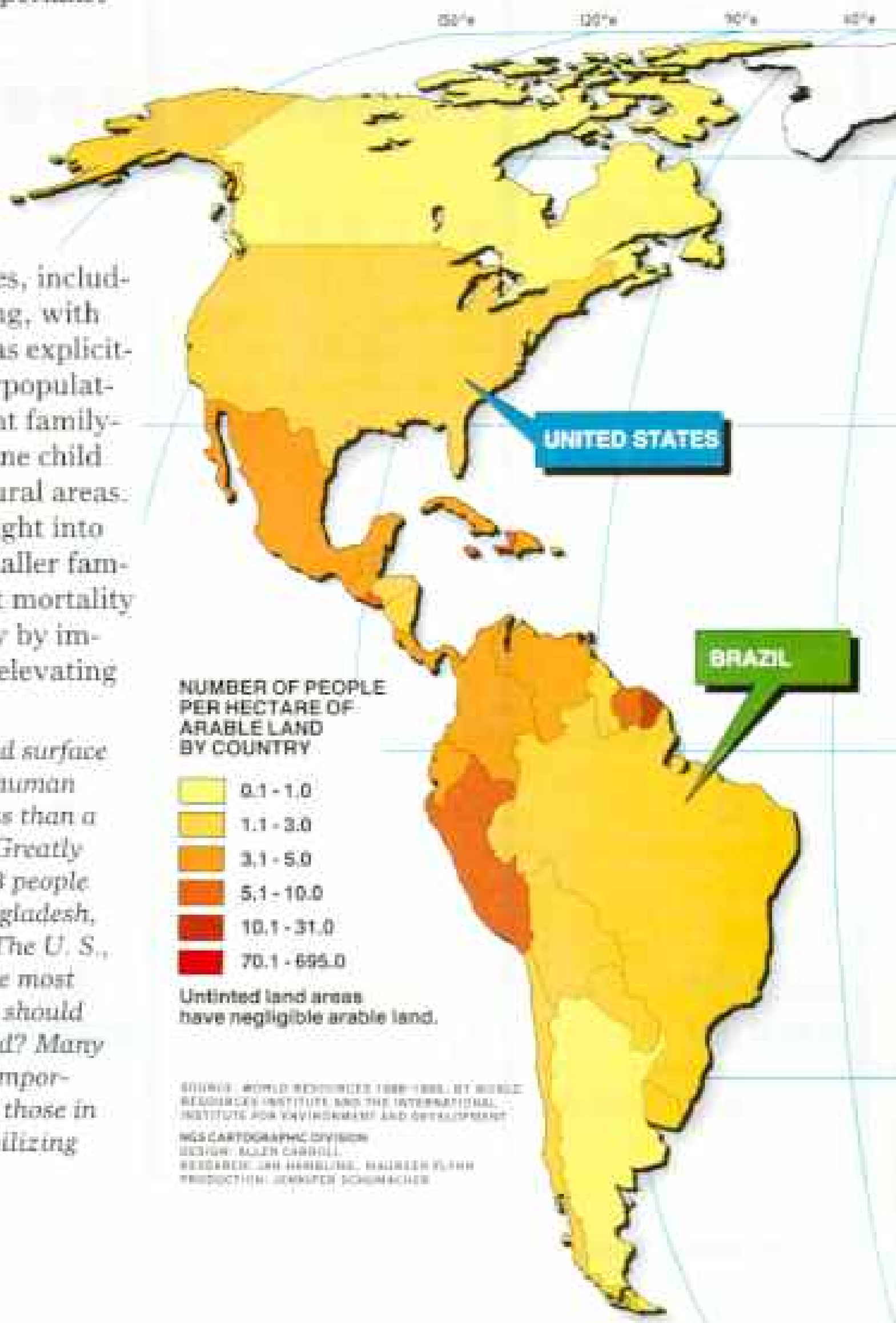
WHILE EFFORTS on the supply side of the human/resources equation are essential, there is no substitute for working on the demand side. Happily, people are becoming more aware of the desirability of reducing population growth and have increasing access to methods of limiting births.

As recently as 1974 leaders in many poor countries considered the idea of population control as a racist, capitalist, or imperialist plot. Today nearly all developing nations have family-planning programs in place. Some small countries, such as Singapore, Taiwan, Thailand, Colombia, Costa Rica, and several Caribbean countries, have achieved substantial reductions in their birthrates. Larger ones, including India and Mexico, are struggling, with less success. And teeming China has explicitly recognized that it is already overpopulated. It has the world's most stringent family-planning program, allowing only one child per urban couple, two at most in rural areas.

Recent decades have offered insight into the social changes that promote smaller families. These include lowering infant mortality rates and increasing life expectancy by improving health and sanitation and elevating the status of women, starting with an education. Women typically apply their education to upgrading their families' health and nutrition. Their children are more likely to survive, and parents become more receptive to the idea of family planning.

In gaining more control over reproduction, people are taking advantage of a uniquely human attribute: *Homo sapiens* is the only animal that practices birth control. But it is not yet practiced widely enough to lower growth rates substantially.

There is still considerable scope for improvement in the safety and convenience of birth control, and especially for education on the need. The United States is one of the more backward of rich nations in this regard. It pays a price with more than a million teenage pregnancies annually, of which more than half are brought to term, and 60



Only 11 percent of the world's land surface is under cultivation; the average human being depends for food on a bit less than a third of a hectare of arable land. Greatly exceeding the world average of 3.3 people per hectare are countries like Bangladesh, with 11.1, and China, with 10.5. The U. S., at 1.3, and Brazil, at 1.8, enjoy the most bountiful cropland resources. But should all potentially arable land be tilled? Many scientists say no, pointing to the importance of great rain forests such as those in South America and Africa as stabilizing influences on earth's climate.

percent of those are born to unwed mothers.

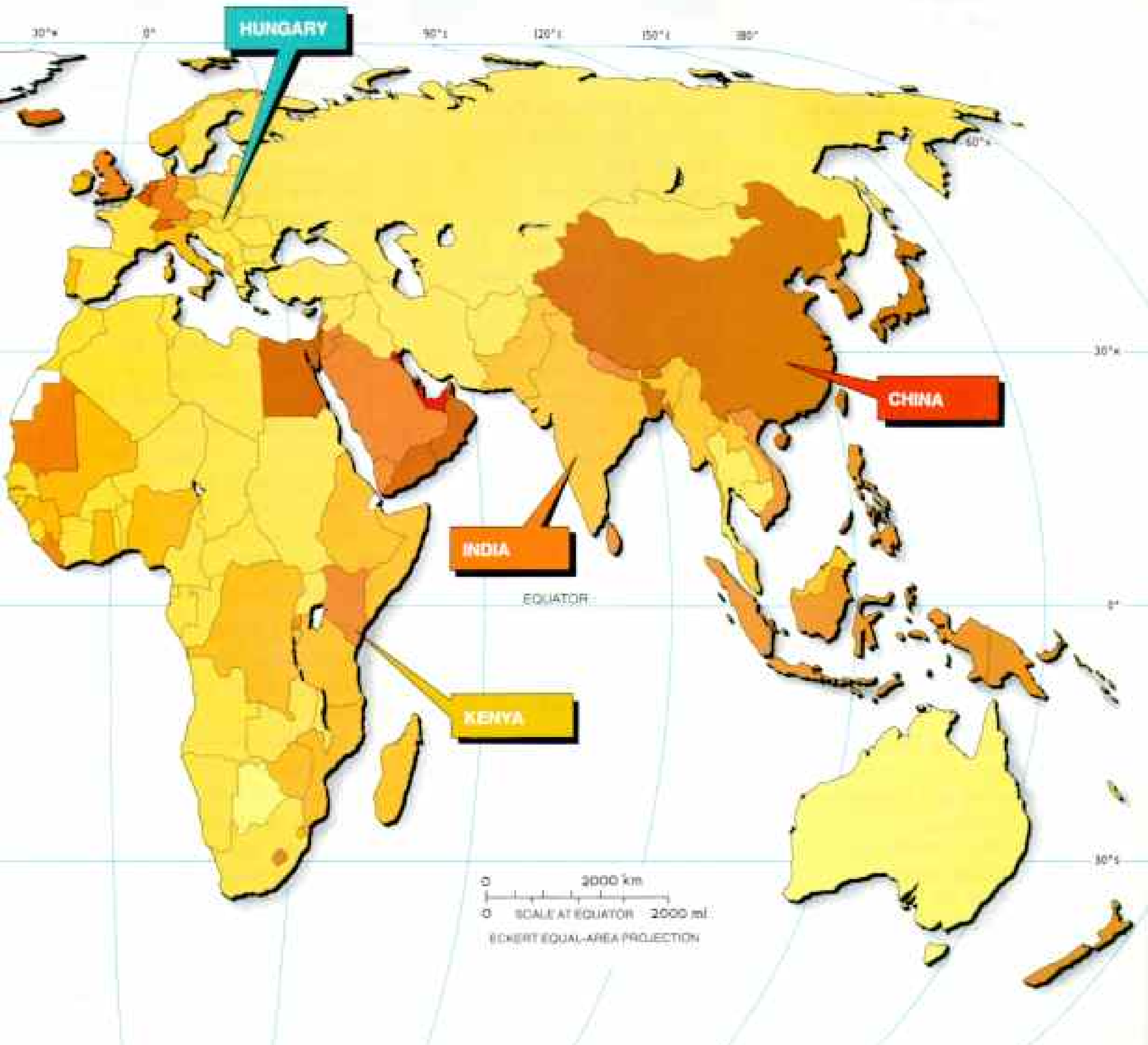
There also is too much dependence on abortion for birth control—a situation that could be aided by wider availability of contraceptive information and materials.

For most of the 3.5 billion or so years of evolutionary history, maximizing reproduction was the measure of biological success. Human beings followed this standard for millions of years. Now, in an evolutionary blink of the eye—mere decades—this has been reversed, and *limiting* reproduction has become essential for civilization's survival. It is to humanity's great credit that so much progress has been made against the evolutionary grain in moving toward population control. We may have a long way to go, but we have come a long way fast.

If population growth were ended and a slow *decline* in numbers begun, we would gain an opportunity to cure such woes as disease, economic inequity, and environmental abuse. But if the rapid expansion continues, none of these can be solved.

Ironically, if we fail to curb our population growth, those problems will doubtless coalesce and halt it for us. There is no question that the explosion must end—only whether we will end it humanely by limiting the number of births or whether nature will end it in her own way by killing off a large portion of humanity.

Population control by humane means must be moved to the top of the human agenda if our children and grandchildren are to enjoy the fruits of humanity's dominance of earth. Our species is capable of providing all its members with a satisfying, productive life in a healthy environment. All we need do is mobilize the will to do so. □



The least you can expect from Honda.

Some people would have you believe that how much you spend on a car is directly proportional to how much you'll enjoy it.

They have obviously never driven a Civic Hatchback.

Because, while this Hatchback is our lowest priced car—and one of the lowest priced cars in America—it is, first and foremost, a Honda.

Which means it has to live up to our high standards before we expect it to live up to yours.

Perhaps that is why the Civic helped make Honda number one in import owner loyalty for the last 11 years.*

And why Civic Hatchbacks are famous for holding their value so well. For example, if you had sold a 1987 Civic Hatchback 12 months after you bought it, it would have retained an impressive 104.5% of its original value.**

In other words, you can get a lot out of a Honda Civic Hatchback. Which isn't at all surprising, when you consider everything we put into it.

Starting with a 1.5 liter, 16-valve, fuel-injected engine. Sixteen valves let the engine run much more efficiently. Programmed fuel injection lets exactly the right amount of fuel into the engine. The Civic is responsive. You'll get a kick out of driving it.

The 4-speed manual transmission will help bring you up to speed. You'll see that shifting is extremely smooth.

While you're changing gears you'll appreciate the responsive rack-and-pinion steering. And the fact that the Civic Hatchback has front-wheel drive, which allows for more interior space and better traction.

One big attraction of the Civic is its stable, comfortable ride.

We attribute this to an advanced double wishbone suspension system. You'll find it on all four wheels of the Civic. You won't find it on any other car in its class.

The multi-control rear suspension makes the car track better, especially in hard cornering. The front suspension keeps the tires nearly perpendicular to the road, which improves stability considerably.

This frees up the springs and shock absorbers to do a better job of toning down bumps and other unpleasantries of the road.

We put gas pressurized shock absorbers in back because they last longer. They don't fade in extreme heat or during hard cornering. And when you're carrying a full load, they help keep things on an even keel.

The double wishbone design was perfect for the Civic because of its compact layout. It leaves more room for people than a strut-based suspension would, and fits nicely under the low Civic hood.

The low hoodline contributes to the Civic's low 0.33 coefficient of drag. So do the near-flush side windows, flush low-profile halogen headlights, flush door handles and rear spoiler.

 *Leading Import Sales Analysis, R.L. Polk & Co., May '88.

**Percentage of MSRP* compared to the retail amount without optional equipment and/or mileage adjustment based on Sept./Oct. 1988 *Kelley Blue Book*. Actual selling price may vary.

Protective side mouldings and front mud guards prevent knocks and pings. The impact-absorbing front bumper is crash tested at 5 miles per hour, twice what the government requires.

In the Civic, how quickly you stop is just as important as how quickly you go. That is why this car uses power-assisted front disc brakes. They are ventilated to dissipate heat and keep stops short and sure. Drum brakes bring up the rear.

We'd like to bring up the 3-year/ 36,000-mile limited warranty. It's new. Your Honda dealer will be happy to give you all the details.

You will like sitting in this car almost as much as you will driving it. The seats are firm, supportive. Both front seats recline and their head restraints adjust to fit you.

There is plenty of room to stretch out in the Civic: front legroom measures 43.3 inches.

This car is very hip, with 54.7 inches of front hiproom, 45.7 inches of rear hiproom. Shoulder room is ample.

And if you ever find yourself in the backseat, you won't hit the roof. There's generous headroom, thanks in part to the distinctive long Civic roofline.

There's a good deal of cargo room, too. When the rear seatbacks are down, you've got 25 cubic feet of space to fill up. Leave both seatbacks up and you still have lots of space for storage. Or, fold them one at a time; they split 50/50. Your Civic is flexible.

Up front, everything you need is close by. The instrument panel is easy to read white-on-black analog. High beam, low beam and windshield wiper controls are literally at your fingertips. Switches are clearly marked.

The low hood makes it easier to see where you're going. So do big side windows. Visibility is excellent.

A rear window defroster lets you see where you've been. It turns itself off automatically after it's cleared things up. And a 4-speed heat and ventilation system lets you go with the flow.

A manual remote-operated driver's mirror can be adjusted conveniently without rolling the window down.

There's also a remote hatch release, a remote fuel filler door release, a trip odometer. And, to help you keep track of your loose change, a coin box.

It was the least we could do.

HONDA

The Civic Hatchback

FROM SEA TO SHINI
SUCCEED IS PART OF T

NG SEA, THE WILL TO HE AMERICAN SPIRIT.

The instant you become an American, whether by birth or by choice, you are guaranteed a particular freedom that is nowhere mentioned in the Constitution, but in fact flows from it.

You are guaranteed the freedom to succeed.

You are free to dream your own dream of success, to study, to work, to create and discover and build, for yourself and your children, the success you want.

Our deep belief in that idea is one reason that our company—Citicorp and Citibank—has grown to become by far the nation's largest financial services organization.

For over 175 years, our freedom to innovate, to create new financial ideas and services, has led to an unbroken line of initiatives allowing us to help countless millions of individuals.

Today, more Americans are pursuing college education and graduate degrees with help from us than from any other private lender.

More are getting what they want with the help of MasterCard® and Visa cards from Citibank than from any other company.

And more Americans who once dreamed of "some day" owning their own homes now own them, or are buying them, with help from Citicorp and Citibank.

Meanwhile, here at home and in 90 other countries, Citicorp and Citibank serve over 25,000,000 customers, companies and governments, in every major world marketplace.

We can help you, or your company, achieve success, here and abroad.

Whether you get to know us as Citicorp or Citibank, we'd like you to get to know us better.

CITICORP

BECAUSE AMERICANS WANT TO SUCCEED, NOT JUST SURVIVE.™

FROM THE PRESIDENT

Centennial Awards

THE NATIONAL GEOGRAPHIC SOCIETY

OUR PLANET, like the delicate crystal globe on its pedestal, deserves the best care we can give it. This simple but powerful idea has guided the Society from the beginning. So it is fitting that in our final centennial issue, we should ask whether humanity is meeting its most basic responsibility.

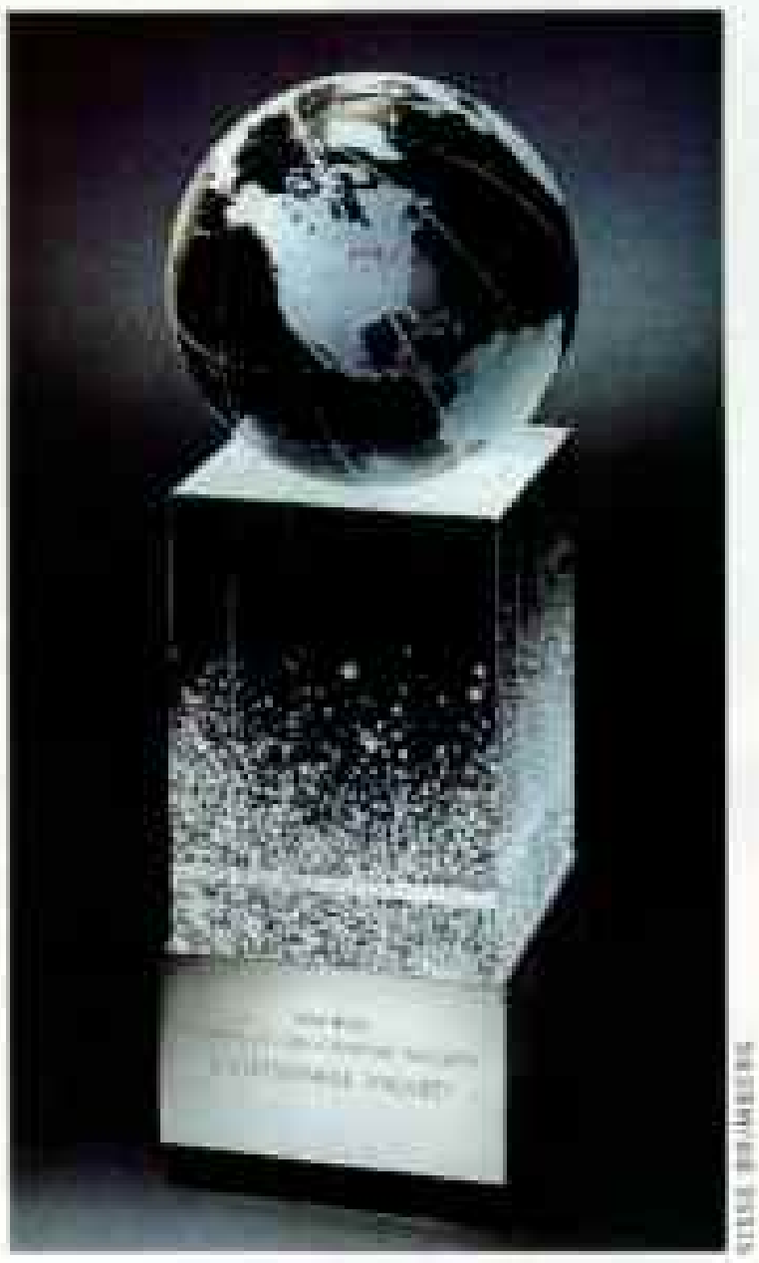
We've posed the question before, of course. And we've been fortunate over the years to enlist the talents of extraordinary people to provide some answers. At a gala on November 17 we honored 15 of these individuals—not only for their contributions to the Society but also for achievements in their own fields, from exploring ocean depths to pioneering space flight. To these 15 we proudly presented the National Geographic Society Centennial Award.

One mark of great individuals is their ability to look beyond areas of expertise to see the larger picture—to understand the problems facing us all and to do something about them. It is gratifying to me that the Society has supported such individuals through research and exploration grants and that we are honoring them with this award.

Consider Jacques-Yves Cousteau. Not content with historic breakthroughs in undersea research, writing, and films, he followed his convictions a step further, establishing the Cousteau Society. With more than 200,000 members, it now actively promotes preservation of the seas.

Or consider Sir Edmund Hillary. He didn't rest after climbing earth's tallest peak but went on to help establish the 480-square-mile Sagarmatha National Park, a joint effort by the governments of Nepal and his native New Zealand to protect the Mount Everest region.

In their own ways the people recognized by this award have reached beyond the achievements that first brought them celebrity—whether it was John Glenn's orbital flight in a Mercury capsule or Jane Goodall's encounters with chimpanzees; "Doc" Edgerton's experiments with the strobe or Thayer Soule's captivating lectures; Mary and Richard Leakey's discoveries about early humans or Bob Ballard's discovery of *Titanic*; the archaeological firsts of Kenan Erim on land or George Bass beneath the sea; the pioneering work of Frank and John Craighead in radiotracking animals; the magnificent maps of Bradford and Barbara Washburn. Each has shown a broad awareness of humanity's place on our planet and has acted on his or her beliefs.



BARBARA WASHBURN
BRADFORD WASHBURN
DR. FRANK C. CRAIGHEAD, JR.
DR. JOHN J. CRAIGHEAD
DR. HAROLD E. EDGERTON
THAYER SOULE
JACQUES-YVES COUSTEAU
SIR EDMUND HILLARY
DR. MARY D. LEAKEY
RICHARD E. LEAKEY
DR. GEORGE F. BASS
SENATOR JOHN GLENN
DR. JANE GOODALL
DR. KENAN T. ERIM
DR. ROBERT D. BALLARD

I've talked with hundreds of people this year at events related to our Society's centennial. Their most frequent question: "What's left to explore? Adventurers have reached the Poles, planted flags on every corner of earth and even on the moon, and probed the ocean floors. What does that leave?"

My reply has been: There's a whole world yet to be discovered, not of mysterious unknown places but of relationships among the places. A century ago great explorers were busy filling in the blanks on the globe. What we haven't filled in yet are the blanks of knowledge about those places, their peoples and environments, and how they all fit together—an even greater challenge.

As we look ahead to our second century, I wish we could use this elegant crystal ball to gaze into the future. I think we'd find the true heroes of our own age asking the tough questions. What kind of world are we leaving our children? Will they live in peace? Will they suffer less hunger and disease? Will they know the pleasures of fishing a mountain lake or taking a plunge into the surf—or will pollutants and ocean refuse have stolen such moments from them? Tomorrow's heroes, like today's, will have the strength and courage to push for solutions. Theirs will be a new kind of exploration, and the quality of our lives will depend on their successes.

Gilbert M. Grosvenor

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Elegance. Luxury. Front-wheel drive. Electronic fuel-injected V-6. Anti-lock

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THE MOST ADVANCED FOUR-SPEED AUTOMATIC TRANSMISSION.
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New Yorker exemplifies Chrysler's belief that you have a right to a quality car with long-term protection. You have a right to a safe car, friendly treatment, honest service, competent repairs and the right to address grievances. Quality is your right . . . and Chrysler intends to see that you get it.

†Some items optional. †† Available on Landau only. * See copies of limited warranties at dealer. Restrictions apply. 5/50 excludes maintenance adjustments and wear items. Deductible on powertrain after 5/00. BUCKLE UP FOR SAFETY.

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CHRYSLER'S CRYSTAL KEY PROGRAM.
BETTER OWNER CARE THAN EVEN ROLLS ROYCE OR MERCEDES.

5-Year/50,000-Mile Basic Car Warranty: Covers the entire car, bumper to bumper. Air-conditioning; engine; powertrain; steering; electrical components; fuel, suspension and engine cooling systems . . . the works.

No Deductible Cost To You: Unlike GM, Chrysler does not require that you pay a $100 deductible after one year or 12,000 miles . . . *each time you bring in your car.*

7-year/70,000-Mile Protection Plan: Even after the basic 5/50 warranty, the engine and powertrain are still protected for 7 years or 70,000 miles.

7-year/100,000-Mile Rust-Through Protection: New Yorker is protected from outer body rust-through for 7 years or 100,000 miles.

Customer Hotline. Chrysler provides a toll-free "800" telephone number for you to call 24 hours a day with any questions on warranty or service.

Chrysler 7/70
Division of Chrysler Motors

CHRYSLER. DRIVING TO BE THE BEST.

CHRYSLER'S CRYSTAL KEY PROGRAM. THE BEST OWNER CARE OF ANY LUXURY SEDAN. BETTER THAN ROLLS ROYCE OR MERCEDES.

	BASIC CAR WARRANTY covers entire car except normal upkeep	MAJOR COMPONENTS PROTECTION	DEDUCTIBLE YOU PAY FOR REPAIR of major components	ENGINE PROTECTION†	POWER-TRAIN PROTECTION†	OUTER BODY RUST-THROUGH PROTECTION	24-HOUR TOLL-FREE HOTLINE
1989 CHRYSLER NEW YORKER	5 years/ 50,000 miles	5 years/ 50,000 miles	None	7 years/ 70,000 miles	7 years/ 70,000 miles	7 years/ 100,000 miles	Yes
1988 ROLLS ROYCE CORNICHE	3 yr/ unlimited	3 yr/ unlimited	None	3 yr/ unlimited	3 yr/ unlimited	3 yr/ unlimited	No
1988 MERCEDES BENZ	4 yr/ 50,000 miles	4 yr/ 50,000 miles	None	4 yr/ 50,000 miles	4 yr/ 50,000 miles	4 yr/ 50,000 miles	Yes
1989 CADILLAC BROUGHAM	4 yr/ 50,000 miles	4 yr/ 50,000 miles	$100 after 1 yr/12,000 miles	4 yr/ 50,000 miles	4 yr/ 50,000 miles	6 yr/ 100,000 miles	Yes
1989 LINCOLN TOWN CAR	1 yr/ 12,000 miles	6 yr/ 60,000 miles	$100 after 1 yr/12,000 miles	6 yr/ 60,000 miles	6 yr/ 60,000 miles	6 yr/ 100,000 miles	Yes
1989 OLDS REGENCY BROUGHAM	3 yr/ 50,000 miles	3 yr/ 50,000 miles	$100 after 1yr/12,000 miles	3 yr/ 50,000 miles	3 yr/ 50,000 miles	6 yr/ 100,000 miles	No
1989 BUICK ELECTRA PARK AVE.	3 yr/ 50,000 miles	3 yr/ 50,000 miles	$100 after 1 yr/12,000 miles	3 yr/ 50,000 miles	3 yr/ 50,000 miles	6 yr/ 100,000 miles	No

*See limited warranties at dealers. Restrictions apply. †Deductible may apply.

For 5 years or 50,000 miles,* you take care of normal maintenance, adjustments and wear items. Chrysler takes care of everything else. That's unlike GM, who gives you only 3 or 4 years of coverage and, after 1 year or 12,000 miles, requires that you pay a $100 deductible . . . *each time you bring in your car.* We even cover engine and powertrain for 7 years or 70,000 miles.* Outer body rust-through, 7 years or 100,000 miles.*

Chrysler 7/70 Division of Chrysler Motors

CHRYSLER. DRIVING TO BE THE BEST.

*See copies of limited warranties at dealers. Restrictions apply. Deductible on powertrain after 5/50.

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WASHINGTON, D. C. 20036

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Members Forum

Annapolis

In June 1965 an impressionable 18-year-old Californian reported to the U. S. Naval Academy and made his first steps toward manhood in a city that became his home away from home. Larry Kohl's article and Kevin Fleming's photography in the August issue took me back through time and memory. Even now, long into a service career, I still experience special excitement in each visit to Mother Crabtown.

MICHAEL P. MCGEE
Warrenton, Virginia

Annapolis would better fit the Camelot ideal if her "royalty" would reserve their community's historic-area streets for pedestrian traffic only, as Europeans have done with many market plazas.

DENNIS B. LEDDEN
Butler, Pennsylvania

A small addition, modestly offered, is that the first name of the community was Todd's Harbor. This according to a 1651 survey that is the basis of the current dimensions now marked out as "historic Annapolis." Subsequent names were Arundel and Anne Arundel, supplanted in turn by Annapolis (all names of British aristocracy). The Scots Protestant Todds married the French Protestant Guerins who arrived at Charleston, South Carolina, from La Rochelle, France—thus providing me with two last names, but no first name.

GUERIN TODD
Alexandria, Virginia

Be careful about the images you project for men and women. On page 182 you describe a male midshipman as "cutting an impressive figure in his Navy blues" while a female midshipman is described as "an attractive brunette from Wyoming, a picture of subdued femininity."

ROBERT H. SCHMIDT
Hopland, California

As the mother of a female Naval ROTC student, I realize how difficult an inspection can be. In the caption on page 187 you said, "women have steadily gained honors and respect." Why undermine those gains with a visual image [of a female midshipman who fainted]? It enforces the misconception that women are the first to go down in a stressful situation.

MARCIA R. YOUNG
Shawnee, Kansas

Hats off to St. Clair Wright for her move to rid her town of power lines; here is an important subject rarely broached. The tangled mass of overhead wire is one thing that distinguishes our scenery from that of Europe. Most cities have programs for undergrounding wire on major thoroughfares, and many new areas are relatively wire free, but new poles and wire are installed faster than others are removed.

RAYMOND DAVIS
Belmont, California

South Korea

Having spent a month teaching graduate school in Korea, I was delighted to see the colorful article (August 1988). However, I was struck by the omission of the religious element. More than 23 percent of the population is Christian. The largest Protestant church in the world, Yoido Full Gospel Church, has a membership of 600,000 plus. The largest Presbyterian and Methodist congregations in the world are in Seoul. At night the skyline is marked by hundreds of red neon crosses, each marking a church.

CHARLES G. SCHAUFFELE
South Hamilton, Massachusetts

On page 242 you say "today few Korean men . . . encourage their wives to work." Yet in the next paragraph Mrs. Min starts to bustle around in the kitchen. On page 244 she is bringing in various dishes of food. People who prepare food work. Servants work. I wish Mr. Gibbons would have written "encourage their wives to work outside the home." Let the GEOGRAPHIC help all of us realize that salary is not a synonym for work.

MARIAN M. POE
Haughton, Louisiana

I deeply love Korea, her culture and people. I have visited, lived, and taught there over a period of 20 years. In April 1987 I went to Dong Guk University just after a demonstration and found students have no appreciation for the good done by the U. S. and their own government, and no understanding of geopolitical affairs. Their leaders are supported ideologically and financially by North Korea. Rhee, Park, and Chun were dictators, but they were also patriots. Chun was the only Korean leader in this century to voluntarily step down at the end of his elected term; he should be praised for his courage.

R. EVERETT LANGFORD
Chapel Hill, North Carolina

This past year on two visits I wanted to see at first hand the problem of student riots. I had to ask a taxi driver to take me to precise locations. There were never more than 10,000 to 15,000 individuals involved, and out of a population of 8.5

RCA. NUMBER ONE WITH THE TOUGHEST CRITICS IN THE WORLD.

Across the country, one American pastime has virtually developed into an American folk art.

The home movie.

Over the course of thirty years, whether on film or videotape, Americans have compulsively shot everything from homecomings to birthdays, Fourth of Julys to church socials.

As a result, they've not only mastered the art of home movies, they've also set the standards for the equipment needed to make them.

So it's no wonder that the camcorder of choice of these movie makers comes from the people that pioneered the technology for home video movie making in the first place. RCA.

For instance, RCA introduced solid-state image sensors into video cameras. The technology which is the heart and soul of the camcorder.

And our technological contributions continue to be on the cutting edge with such products as the Super VHS camcorder. A camcorder so sophisticated it produces the sharpest VHS image of any currently available.

Our technological innovations have ultimately become technological milestones in the industry, which is why Americans buy RCA camcorders more than any other.

RCA camcorders. Built to the standards set by those who shoot the most important movie material of all. Life itself.

RCA

million it was difficult to realize that a drastic problem existed. Of course the media throughout the world make everything look many times bigger than it is. I want readers to know that Korea is a wonderful, unusual, dynamic country. Your fine article opens the eyes and hopefully the hearts of many who would want the rare experience of seeing that country firsthand.

HENRY N. EHRLICH
Los Angeles, California

The swastika is not confined to the East. It was used on Mesopotamian coinage and appeared in early Christian and Byzantine art and among the Navajo and Maya. But it is important to make a distinction between the right-hand swastika, associated with the Nazis, and the left-hand symbol, more correctly called the sauvastika, appearing on the Buddhist temple (page 241).

ROBERT M. TUFTS
Austin, Texas

Kyongju

After living for 25 years away from my homeland, the uniqueness of Korean culture has become more vivid to me looking in from the outside. Cathy Newman portrayed this uniqueness with warmth and curiosity. Her effort is a rare one. H. Edward Kim captured a dramatic view of Chomsongdae observatory that reminds me of the glory of the Silla kingdom. Its peculiar

bottle shape is not only graceful but also contributes to its stability and longevity. As a structural engineer, I have studied this stability for 16 years. Internal bracing stones and compacted earth fill inside are the ingenious construction techniques adopted by the Silla builders.

DOUGLAS DONGWOO LEE
Fort Worth, Texas

Korea was a semi-independent state associated with and colonized by China until the early 20th century. Korea's culture, religion, and art, then and now, and even its language and last names are deeply influenced by Chinese culture. Confucian thought originated in China. You never mentioned these facts in your articles, but they can't be historically denied.

NIEL S. LIEU
Calgary, Alberta

"Ancestor worship" (page 267) is not quite accurate. Ancestor respect would better describe the ceremony when people visit graves, present food, and bow. It is similar to our own Memorial Day. Koreans believe that respect for a family member does not end with death. Some Korean Christians take part in such memorial ceremonies.

THOMAS A. DUVERNAY
Harbor Spring, Michigan

Lemurs

Overland travel to all shores of Madagascar convinced me that the Malagasy have a gold mine in their unbelievable natural wonderland (August 1988), which to me as a naturalist was as spectacular as a trip to the moon. A better understanding of the island's potential may help check its deterioration. Bringing tourists in carefully controlled groups could boost the economy, and restoration of destroyed habitats may provide more food for the Malagasy than they gain by exploiting them.

JOHN DALLAS HALLAHAN
Media, Pennsylvania

Photographing Madagascar's lovely creatures for study and to give the public a rare glimpse is one thing. Turning over to a zoo two fossas that were trapped to photograph is reprehensible.

JACKIE GEYER
Pittsburgh, Pennsylvania

Remington

Your outstanding article "C. M. Russell, Cowboy Artist," January 1986, caused us members of the Society to marvel. We asked, "Why not Remington too?" We had our answer this August, and it was just as great.

EDUARDO VETILLO
DARIO POCI
São Paulo, Brazil

Referring to the caption under the painting "The Stampede," the words wrangler and cowboy are not interchangeable; those riders are cowboys.

THOMAS MARZA
Brown Bear Ranch
Wickenburg, Arizona

Lexicographers wrangle over this distinction.

The story is marred slightly by the description of Wounded Knee Creek. There were 230 women and children and 120 men under the leadership of old Big Foot. Only one man is known to have resisted giving up his rifle, and he reputedly was deaf and could not understand the command. Your article states that "dozens of women and children perished," but in fact only 50 of the 350 survived the massacre.

JAMES L. MATHIS
Greenville, North Carolina

Last year in Sydney I saw a great exhibition from America titled "Art and the West," at which I was exposed to several of Remington's bronze sculptures and paintings. I now appreciate even more the talent of this man. Thanks to all who work so hard to make GEOGRAPHIC stimulating—you make a "feeling" contribution to what sometimes seems a rather "plastic" world.

JANE LAMBERT
Brisbane, Australia

Anniversary Issue

Your 100th-anniversary issue was great (September 1988). According to our local newspaper, on August 17 there was a burglary of a garage in our community, and 15 years of NATIONAL GEOGRAPHIC magazines were stolen. I suppose the burglar used a truck. I have 12 years of issues in my basement. I guess I had better put a stronger lock on the cellar door.

MARLENE HELLMAN
Piedmont, California

Regarding the President's Page in September, if the GEOGRAPHIC thinks so much of the discovery of the Valley of Ten Thousand Smokes in Alaska that you mention it twice, why then do you not mention the name of the discoverer? Robert F. Griggs discovered the nearly ten million fumaroles; Gilbert H. Grosvenor, your early Editor, took pains to get the highest nearby mountain named Mount Griggs. My father named nothing for himself, but he did name previously unnamed features that he explored: Geographic Harbor, Lake Grosvenor, Mount LaGorce, and Mount Martin to honor the National Geographic Society.

RUTH GRIGGS HIGBIE
Reva, Virginia

Your 100th-year issue shall take its place with honor alongside the treasured archives of GEOGRAPHICS in our house. Geography may be a problem for many children today but not for those of us who were literally weaned on the magazine, especially in the 1940s and '50s. However, I find it disturbing that the pen and camera of Jean and Franc Shor, who played such a large and unforgettable role in bringing diverse pieces of the world to so many readers, would be mentioned only in passing. The wonders, strangeness, and beauty of foreign lands became vivid, super-real, and appreciated, as they shared their experiences with us.

GERARD SPANIER
Linwood, New Jersey

For the timeless articles by Jean and Franc Shor, see November 1950, March 1951, May, June, and November 1952, March and October 1953, August 1954, February, March, and April 1955, January and October 1956, May 1957, March and October 1958.

Your in-depth treatise on Alexander Graham Bell (September 1988) provides an appreciation of his da Vinci-diverse interests of which I had been only vaguely aware. However, relegating his photophone to the status of having no commercial value may have been premature, given the basically sound principle of transmitting

GIVE SOMEONE A HIT ALBUM FOR CHRISTMAS.

Look no further than your local post office or philatelic center for Christmas presents that special someone will love.

Help to start a stamp collection or add to it. Either way, here are some long-playing albums and other gifts that will be hits all year long.

This Year's Greatest Hits.

The 1988 Commemorative Mint Set is an album for collectors and non-collectors alike.

It includes all the commemorative stamps issued in 1988, complete with stories about each and mounts to affix the stamps in the album.

There's no better way to start a collection or to add to one.

A Complete Collection of Folk.

This Christmas, a special mint set features the folk art stamps issued by the U.S. Postal Service since 1978. Carousel animals, woodcarving figurines, and Navajo art are just a few examples of the hits in this collection.

Oldies and Goodies.

The Postal Service Guide to U.S. Stamps is an encyclopedia of all U.S. stamps ever printed. Each stamp, starting with the first issue in 1847, is reproduced in full color. Learn about famous stamp collectors and get all sorts of information on collecting and collecting terminology.

Make Beautiful Notes.

These cards are based on the U.S. Postal Service's just-issued classic car stamps.

Get a set to mail to your friends or start a collection of cards and matching stamps.

You can get an education in the golden years of auto-making while you learn more about stamps.

Collect U.S. Stamps.
They're alive.

communications via a modulated light beam. His concept was extended with development of fiber optics and lasers that eliminate the transmitting-medium obstructions and beam divergence in the air (and generate adequate beam intensity), which thwarted Aleck's initial efforts. In view of today's applications, perhaps Bell also enjoyed prophetic talent in rating the photophone as his greatest invention.

T. KIRKWOOD COLLINS
Salt Lake City, Utah

Philipp Reis was never mentioned in the fascinating Bell article. Even if he made his instrument out of a beer-barrel bung and bratwurst, Reis named it the telephone, and Europeans are convinced, especially in the fairy-tale town of Gelnhausen, Hessen, that he invented it. His work was the leading reference in patent fights.

MORGAN C. LARKIN
Salem, Oregon

Reis's instrument transmitted tones, not speech.

The opening statement that "Everyone knows that Alexander Graham Bell invented the telephone" exaggerates the meaning of everybody. It might more accurately read that Bell invented a telephone and was successful in the wake of great controversy and litigation in protecting his patent. I find merit in the minority opinion of Justice Bradley in the case of the *People's Telephone Company v. American Bell Telephone Company* decided by the U. S. Supreme Court in 1888. The court was asked to invalidate Bell's patent on the grounds that the telephone was first invented by Daniel Drawbaugh of Eberlys Mill, Pennsylvania; this the Court refused to do. Justice Bradley wrote: "We are satisfied from a very great preponderance of evidence, that Drawbaugh produced, and exhibited in his shop, as early as 1869, an electrical instrument by which he transmitted speech. . . . [He] invented the telephone without appreciating the importance and completeness of his invention. Bell subsequently projected it on the basis of scientific inference, and took out a patent for it."

FORREST S. SHEELY
Salem, Indiana

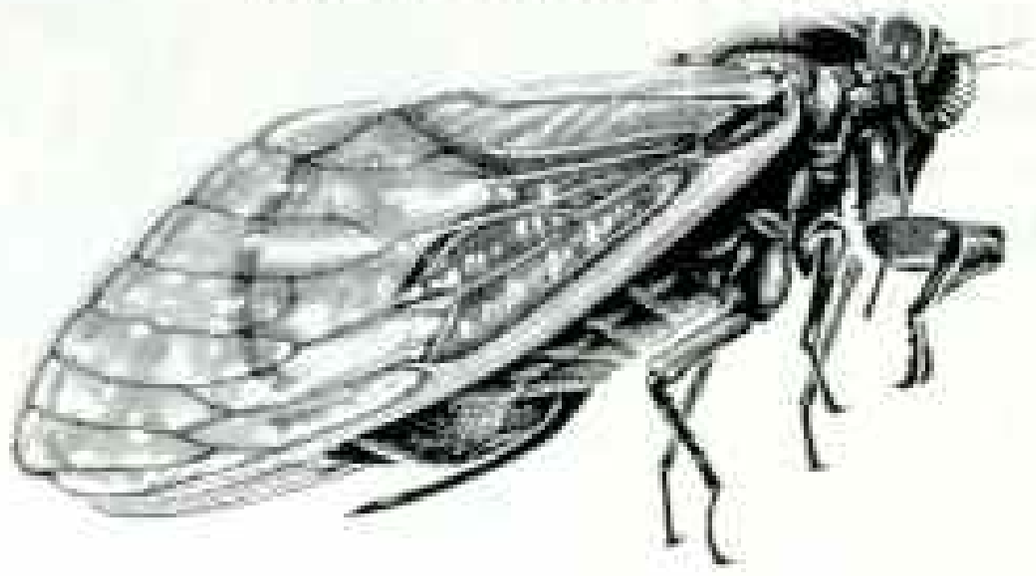
Not until 1880 did Drawbaugh claim in court to have invented the Bell telephone, the Edison transmitter, and other improvements. Asked to explain his experiments, he replied, "I don't remember."

Letters should be addressed to ***Members Forum,*** *National Geographic Magazine, Box 37448, Washington, D. C. 20013, and should include sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.*

Alarm clock of the insect world

They may be the most mysterious of all insects. They certainly enjoy the longest life cycle. They are the periodical cicadas of the northeastern United States, and they ring in every 17 years. No one knows how their biological clock works, but we know it has been working with precision since the Pilgrims noted the insects, mistaking them for locusts.

Cicadas tunnel into the ground after hatching and stay there,



sucking root fluids, for 17 years. Then they emerge by the millions in late May and early June. Shedding their skins and hardening into maturity, they climb into trees. The males "sing" an immensely noisy mating song by vibrating membranes on their abdomens. After mating, females deposit 400 to 600 eggs in slits in branches. In six to eight weeks the nymphs hatch, drop to the ground, tunnel under, and start the cycle all over again.

Despite the cicadas' bulging red eyes and gaudy orange wings, birds, cats, and dogs gobble the defenseless insects. "They are not a health threat to humans," entomologist Gene Wood told the National Geographic News Service, "so we might as well enjoy them while we can."

Room for the whole crew.

It seems most mid-size cars these days barely have enough room to accommodate your elbows, let alone a whole crew.

But we've changed all that with the launching of a space vehicle. The new Sonata from Hyundai. Inside the Sonata you'll discover deep space. An astronomical 100 cubic feet of it. Which adds up to more passenger room than any other car in its class.

And it's comforting to know that the Sonata GLS comes equipped with the right stuff. Like cut-pile carpeting and reclining bucket seats. A fold-down 60/40 split rear seat with a disappearing armrest. There's even a whole galaxy of standard features like power windows and power door locks. And an electronically tuned AM/FM stereo cassette with 6 speakers. We've also included an optional sunroof for views that are out of this world.

When you're ready to take off there's a fuel-injected, 2.4-liter overhead-cam engine waiting under the hood. It's the most powerful standard engine in its class. And coupled with front-wheel drive, the Sonata can really fly.

Hyundai has a reputation for going the distance, so every Sonata is backed by our 36 month/36,000 mile Bumper-to-Bumper limited warranty (with no deductible required).* Each new Sonata owner also receives free membership in the Cross Country Motor Club.* And, because it's a Hyundai, you can be sure it's priced down to earth.

For the location of your nearest Hyundai dealer call 1-800-826-CARS. And test drive the new Sonata. It's a move that'll sit well with the crew.

The Sonata from
HYUNDAI
Cars that make sense.

*See dealer for warranty details. © 1988 Hyundai Motor America. Seat belts make sense.

PROOFS OF AN ENRICHING EXPERIENCE.

Announcing the 60 winners of the Mazda Photo Contest '89.

There's a lot to be said for owning a Mazda. And once a year we encourage Mazda owners to say it in photographs. This year's pictures again speak of fun and adventure, and the truth is, Mazdas improve the quality of life wherever they are found.

Congratulations and money go to our contest winners. Congratulations, in fact, are due every contestant. Because while many of you may not have been rewarded financially, your photos suggest enrichment of other kinds.

First Prize Winners

Francois Delbrassa
(Quebec, Canada)

Hermann Schlattner
(Mittersg-Pachstein, Austria)

Stuart Dee
(British Columbia, Canada)

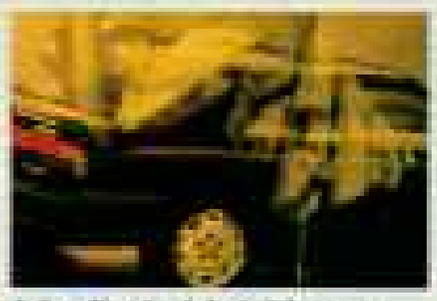
Erna Indrawati Soebroto
(Malang, Indonesia)

Simon Myrberget
(Nesodden, Norway)

Ralph E. Duncan
(California, USA)

Johann Frank
(Melk, Austria)

Michael Knudsen
(Mandelabrup, Denmark)



John Frederick Ashburne
(Gymna, Japan)

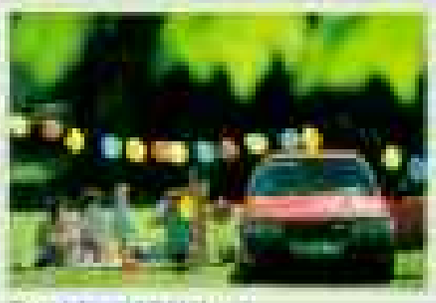
Bryan Ilg
(Florida, USA)

Sam Grimm
(Florida, USA)

David Haskell
(Ontario, Canada)

Kek Tiam Kiow
(Johor, Malaysia)

Libby Clark
(Virginia, USA)



Burkhard Hilbert
(Kalil, West Germany)

Second Prize Winners

Beda Widtmer (Tarrenz, Austria)
Johann Rath (Wien, Austria)
Sepp Wiedenhofer (Wien, Austria)
Beni (Mandalay, Burma)
Frankie Tun Tin (Mandalay, Burma)
Ko Win Myint (Rangoon, Burma)
Maung Maung Gyi (Mandalay, Burma)
Mg Mg Hla Tint (Rangoon, Burma)
U Kyi Win (Rangoon, Burma)
Charles Cangrain (Quebec, Canada)
Irene Smith (British Columbia, Canada)
Philip S.G. Kor (Ontario, Canada)
Robert G. Armstrong
(British Columbia, Canada)

Pedro Franco (Medellin, Colombia)
K. Prasetya (Bali, Indonesia)
Kuniyoshi Hayashi (Shizuoka, Japan)
Pippa Zammit Cutajar (Birma, Malta)
Keiron Grey (Skarnes, Norway)
Carrie Bennett
(Lae, Papua New Guinea)
Peter Truong
(Jalan Mas Kuning, Singapore)
Jan Kopes (Johannesburg, South Africa)
Robert d'Avice (Durban, South Africa)
Silvani Sigi (Lucerne, Switzerland)
P. van Langh
(Oosterhout, The Netherlands)

Alan Wake Green
(London, United Kingdom)
David W. Hay
(Perthshire, United Kingdom)
Alex Viarnes (California, USA)
Andrea Pellicani (California, USA)
Chris Hagelstein (Texas, USA)
Cliff Faulner (Washington, USA)
Curtis W. Martin (California, USA)
Doug William Driver (Oklahoma, USA)
Gerald Milnes (West Virginia, USA)
Kenneth Libby (Hawaii, USA)
Marc Estrada (Florida, USA)
Michael Steinbaum (California, USA)

Nahed Hamdi (California, USA)
Patty Sheahan (Michigan, USA)
Thomas B. Kelly (Texas, USA)
Virginia L. Breckenridge
(Arizona, USA)
Alfons Hab (Neuhaber, West Germany)
Fritz Ittner
(Wilhermsdorf, West Germany)
Herbert Wittmann
(Ebenhofen, West Germany)
Karl-Heinz Schaber
(Karlsruhe, West Germany)
Walter Frankenhauser
(Solzfeld, West Germany)

FURTHER PROOFS ARE WELCOME.

Announcing the Mazda Photo Contest '90.

We know people the world over are having fun with Mazda cars and trucks. All you need to do is prove it. So get your camera ready, and we'll soon tell you how to enter next year's contest.

mazda

DECEMBER 1988

GEOGRAPHICA

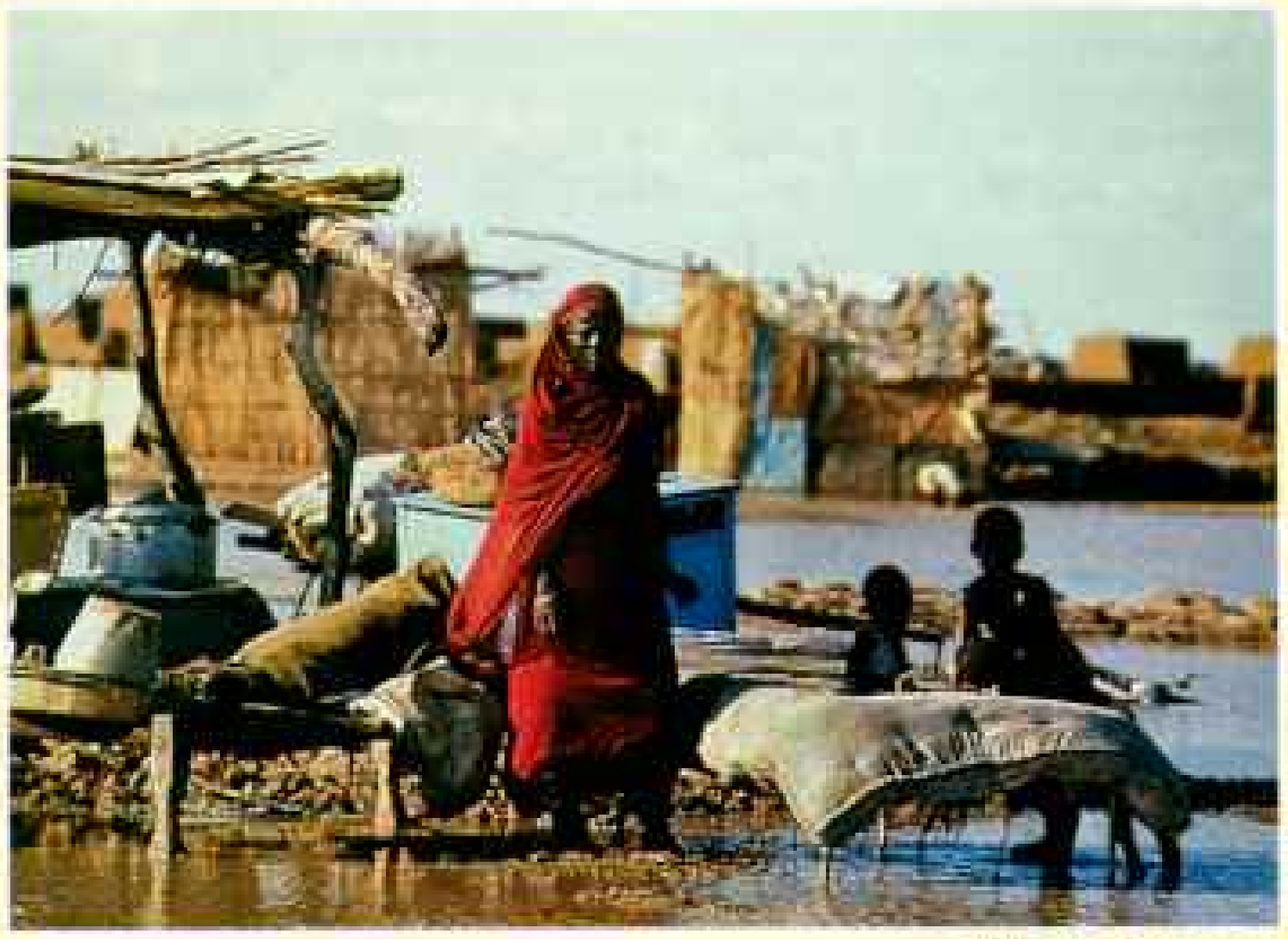
NATIONAL GEOGRAPHIC MAGAZINE

A Change of Fortunes on the River Nile

Early in 1988 Egypt faced disaster. A decade of drought in Africa, especially in Ethiopia—which supplies much of the Nile floodwater coursing through Egypt each summer (NATIONAL GEOGRAPHIC, May 1985)—had left the river dangerously low. Lake Nasser was as low as it had been since the High Dam at Aswan began operations in 1964. Authorities considered reducing Egypt's production of electricity and limiting the amount of water released for irrigation.

Then the rains began. In one 13-hour period in August, eight inches of rain fell on Khartoum in Sudan, Egypt's southern neighbor, where the White and Blue Niles meet. The city had seen only one inch of rain in all 1987. The resultant flooding left more than 1.5 million Sudanese in the metropolis homeless (right).

Meanwhile, rain in Ethiopia raised the Blue Nile to its highest level since 1946. By September, when the rainy season ended, the Nile started to flow at normal levels again. Eventually it will replenish Lake Nasser, and the dam will operate at capacity, supplying electricity and water to Egypt for years to come, or at least until the next drought occurs.



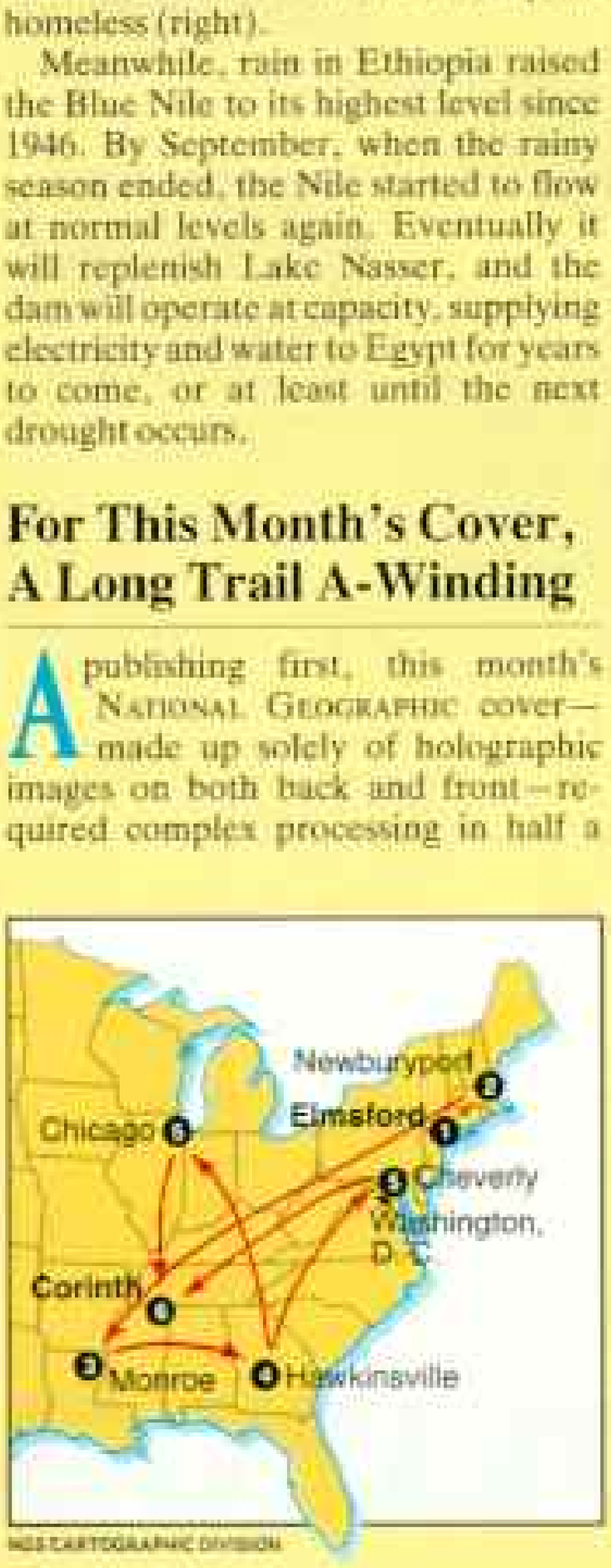
STUART NICOL © SIPA PRESS

For This Month's Cover, A Long Trail A-Winding

A publishing first, this month's NATIONAL GEOGRAPHIC cover—made up solely of holographic images on both back and front—required complex processing in half a dozen plants located across the eastern United States. Never before has any magazine published an entirely holographic cover; no ink was used on the front, spine, or back.

The front-cover image and back-cover advertisement are composed of microscopic ridges—20,000 to the linear inch and visible only with a powerful microscope. These relief images were electroplated on pieces of pure nickel that were joined together. This composite image was replicated 10.8 million times on rolls of clear plastic at American Bank Note Holographics, Inc., in Elmsford, New York. The rolls then traveled to Newburyport, Massachusetts, to be metallized in a vacuum using a process that deposits a film of aluminum on the plastic. Trucked to Monroe, Louisiana, the wafer-thin, foil-like material was laminated to our usual cover-paper stock, given a gold tint, coated to protect against scratching, and baked in enormous ovens to cure the adhesive and coating.

On to Hawkinsville, Georgia. There the rolls were cut into four-cover sheets by a machine purchased specifically for this project. The sheets then were separated, and printing was added to the inside of the covers at either Cheverly, Maryland, or Chicago, Illinois. Finally at the Krueger Ringier plant in Corinth, Mississippi, where NATIONAL GEOGRAPHIC is printed, the covers were bound to the magazine pages before shipment to your door.



NGS CARTOGRAPHIC DIVISION

Durable Voyager 2 Flies on Toward Neptune

Voyager 2, which beamed back pictures of Uranus in 1986, is on a new mission: a close encounter with Neptune next August. Scientists at the Jet Propulsion Laboratory in Pasadena, California, are awaiting their first good look at that planet, 2.8 billion miles from the sun.

The durable spacecraft, launched in 1977, is now taking pictures to determine Neptune's brightness to help calculate the best exposures for the 1989 portraits. Voyager 2 handlers will make course corrections to pass close to Neptune and its moon. Because the planet is so distant, clusters of antennas around the world will team up to receive the data contained in the spacecraft's weak signals. After passing Neptune, Voyager 2 will continue on its endless voyage, reporting on the realm beyond our planetary system.

Rethinking the Big Bang: Maybe It Didn't Happen

Most scientists believe that the universe began with a big bang between ten and twenty billion years ago (GEOGRAPHIC, June 1983). The entire universe was compressed into an infinitely small, dense concentration of matter called a singularity. At the instant of the big bang, the singularity exploded outward in an act of

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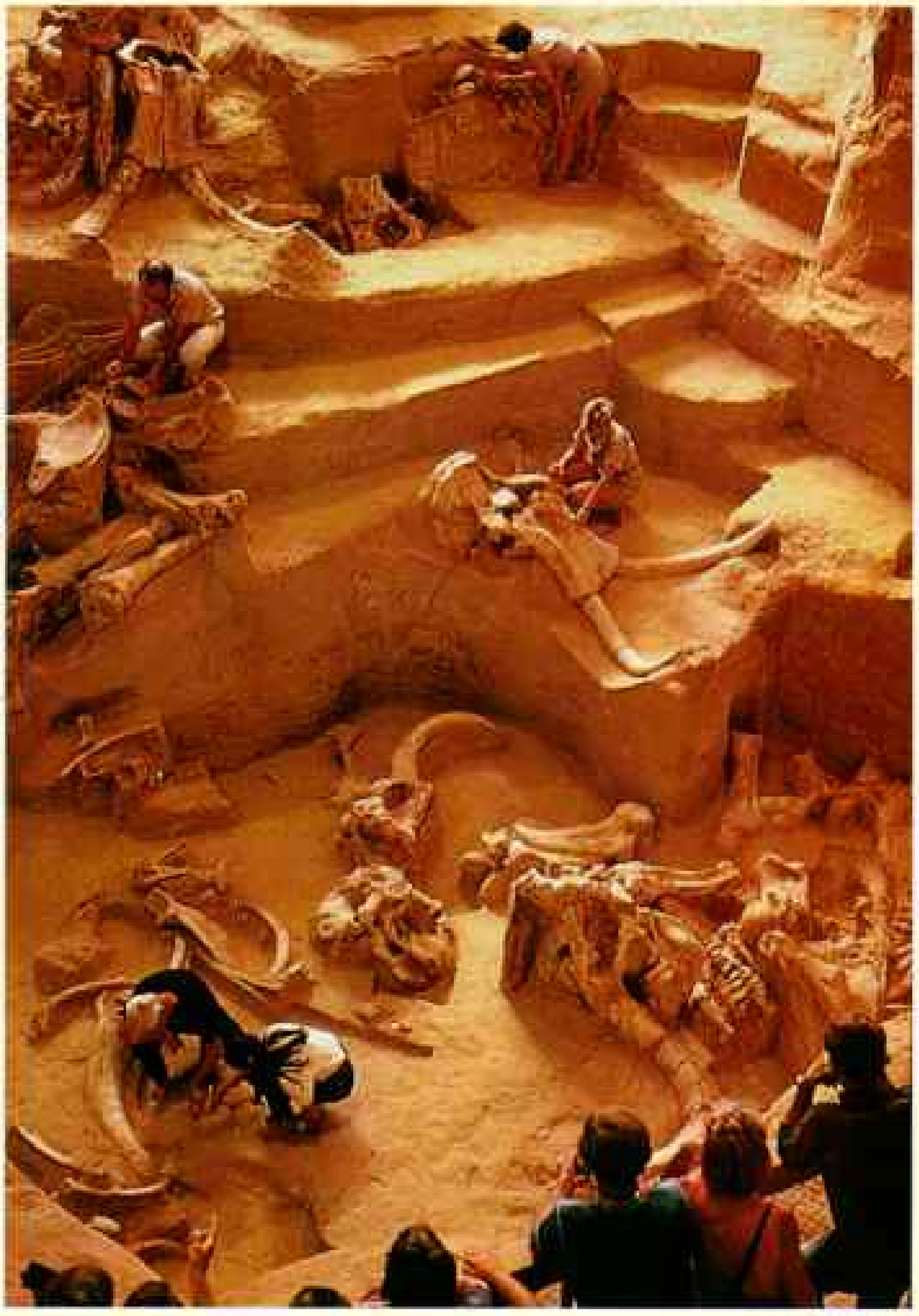

JIM RICHARDSON

creation that accounts for all the matter in our universe today. Stephen W. Hawking of Cambridge University, one of the world's most respected theoretical physicists, was a chief proponent of the big bang principle. But he no longer believes that the universe is an infinite process.

"I believe that space-time is finite," he says, "but without boundary or edge—like the surface of the earth, which is finite but doesn't have any edge." If Hawking is right, the universe could neither be created nor destroyed. "It would just BE," he says.

Uncovering the Bones in a Mammoth Graveyard

The mammoths came to drink at what they thought was a pond. They were mostly typical adventurous adolescents, out from under the protection of older beasts. But the "pond" was a trap: a large sinkhole with steep, slippery walls. One by one over the centuries the young Columbian mammoths, cousins of the better-known woolly mammoths, climbed down and couldn't get out. They drowned or starved and were buried there for 26,000 years—until 1974, when a housing developer at the South Dakota site began turning up bones with his bulldozer.

Larry Agenbroad of Northern Arizona University has been directing the scientific excavation of the Hot Springs Mammoth Site since then, with support in part from the National Geographic Society and with Earthwatch volunteers. The site (left) is the largest collection of Columbian mammoth fossils in the Western Hemisphere. Agenbroad and his crew have found at least 43 individuals. Pollen samples and the remains of other animals offer a clearer understanding of the ancient environment, especially the climate, as it existed when the mammoths came to drink.

Prairie Preservation: Good News, Bad News

The Long Island, New York, chapter of the Nature Conservancy (page 818) has signed an agreement with Nassau Community College to preserve the last 19 acres of one of the few true prairies east of the Appalachians. Those 19 acres are the last remnant (below) of a 60,000-acre stretch of grassland once known as the Hempstead Plains. Tall buildings and highways ring the tract, home to 147 species of wildflowers and native grasses.

Just west of Chicago a larger portion of prairie—800 acres—is thriving (GEOGRAPHIC, January 1980). "We're getting more species of plants, we've had 200 species of birds, and coyotes and beaver are coming in—on their own," says consultant Robert Betz of Northeastern Illinois University.

But a major goal still eludes prairie preservationists: creation of a tallgrass prairie national park. Plans for a park on a 16-by-23-mile prairie northwest of Tulsa, Oklahoma, have stalled in the U. S. House of Representatives. Advocates of the proposal hope to revive it when Congress convenes next year.

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NATIONAL GEOGRAPHIC MAGAZINE

ON OUR HOLOGRAPHIC COVER an elegant crystal earth shatters after being hit by a bullet. True, human destruction of the real planet moves slower than a bullet, but unless we change our ways, the result will be just as shattering.

Our language already resounds with worrisome phrases: ozone holes, greenhouse effect, global warming, solid waste, pesticide poisoning, extinct species, acid rain—all bad news for mother earth, in its own way as fragile as the finest crystal. If present population and pollution trends continue, the coming decades will see millions more acres of agricultural land scorched into worthless desert, and on an overheated earth ice caps will melt, raising sea levels and inundating cities and shorelines. With added billions of people struggling to survive, poverty and starvation inevitably will provoke massive political unrest and violence. Faced with an environmental apocalypse, we must and we will change our destructive patterns. But when?

Must we—like alcoholics and drug addicts—reach bottom before we turn back? Where are the Muirs and the Powells of today to lead us to a more enlightened use of the earth? Environmentalists who have been sounding alarms are scorned as impractical radicals and ridiculed as tree huggers. Most political rhetoric now acknowledges the problems—but it is still devoid of courageous solutions.

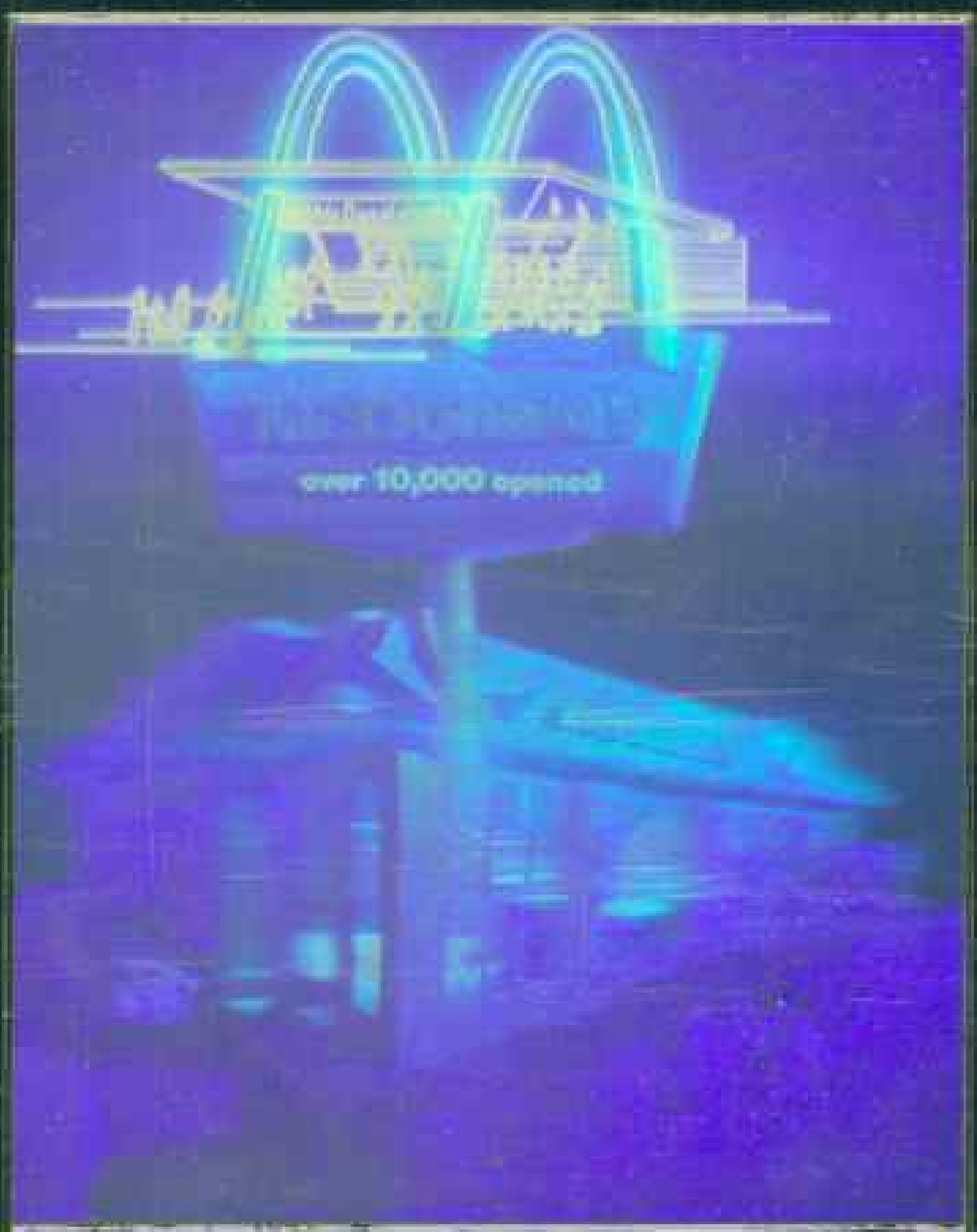
Four decades ago President Roosevelt pooled scientific talent to produce the first atom bomb in 37 months. Why haven't we already looked beyond nuclear disarmament to muster the world's top talent to achieve fusion power within this century? With fusion we could slow the burning of fossil fuels—a horrible waste of chemicals too valuable to be sent up in smoke and turned into acid rain and a warming layer of carbon dioxide. Petrochemicals that took millions of years to create are being depleted in a blink in the life of the planet. And like the thousands of species that become extinct each year, when the fossil fuel is gone, it's gone forever.

A quarter of a century ago President Kennedy excited the nation and the world with the impossible dream of landing a man on the moon within the decade. Today simply cleaning the air we breathe presents a tougher and more urgent goal, but where are the people who say "make no small plans"—and mean it?

As we close our centennial year with this issue devoted to the environment, we can hope that the graphic and technical excitement of our cover and the articles that follow inspire just one leader to create a "giant leap for the environment."

Wilbur E. Garrett

EDITOR



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Key to '88

A YEAR TO REMEMBER, 1988 has been our centennial, and you can see how we celebrated it with this key. We relived the Society's past and the era in which we grew. We honored Australia's bicentennial and devoted the last three issues to peopling of the earth, the zeal for exploration, and stewardship of the planet.

SIX-MONTH INDEXES ARE FREE upon request. The January-June index (Vol. 173) is available now; July-December (Vol. 174) will be ready in January. Write to National Geographic Society, Washington, D. C. 20036.

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In the age of the dinosaur, the earth lost a single species every thousand years. Today, we lose one every single day. At this horrifying rate, by the year 2000, one out of every five species now on the face of the earth will have disappeared.

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And buy it we have. To date, we have privately secured more than 3 million acres. (That's more land than Delaware and Rhode Island combined.) We're protecting wetlands in the Carolinas, prairies in the Dakotas, deserts in the Southwest, islands off the coast of New England, rain forests in Latin America. With 1100 preserves, we've created the largest private sanctuary in the world today. And literally every single day, we protect just about 1000 acres more.

We are not dreamers. We are pragmatists. We recognize that the destruction of each species brings us closer to the extinction of our own. We've also come to understand that in allowing one species to vanish, we may be losing forever the cure to a disease or the solution to a famine.

But faster than we can buy up the land, man is encroaching upon it, polluting it, eliminating it. Which is why we need your help.

Buying back the earth takes lots of money. And most of our support comes from our members. If you have $10, $20, or $50 to give to become a member of The Nature Conservancy, you'd be advancing our cause dramatically.

Buying back the earth is ultimately the job of each of us—the people of the earth. Dollar by dollar, acre by acre.

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The Nature Conservancy

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Clockwise from above right:
Golden Headed Tamarin, Whooping Crane, Florida Panther, Manatee

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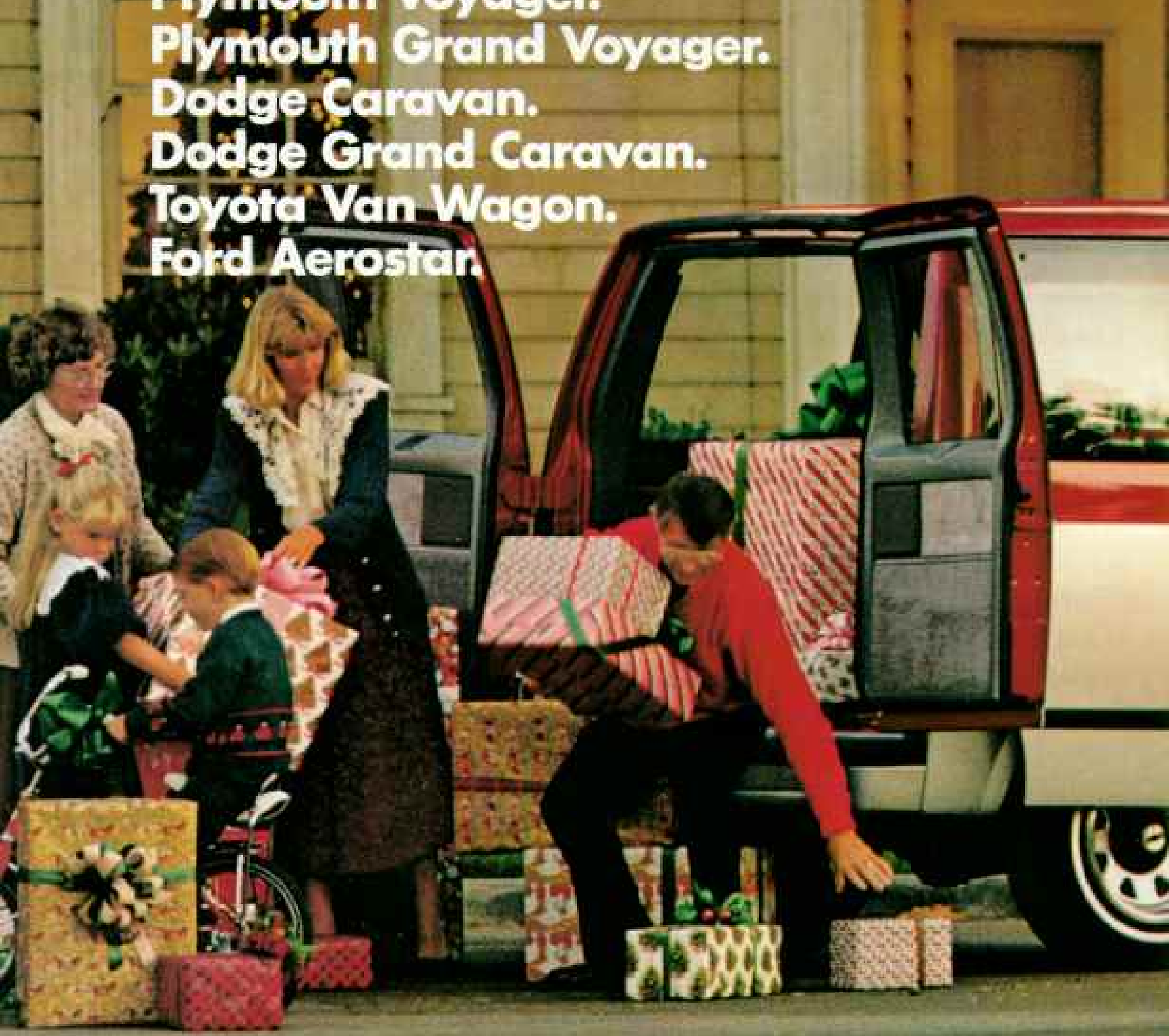

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THE *Heartbeat* OF AMERICA

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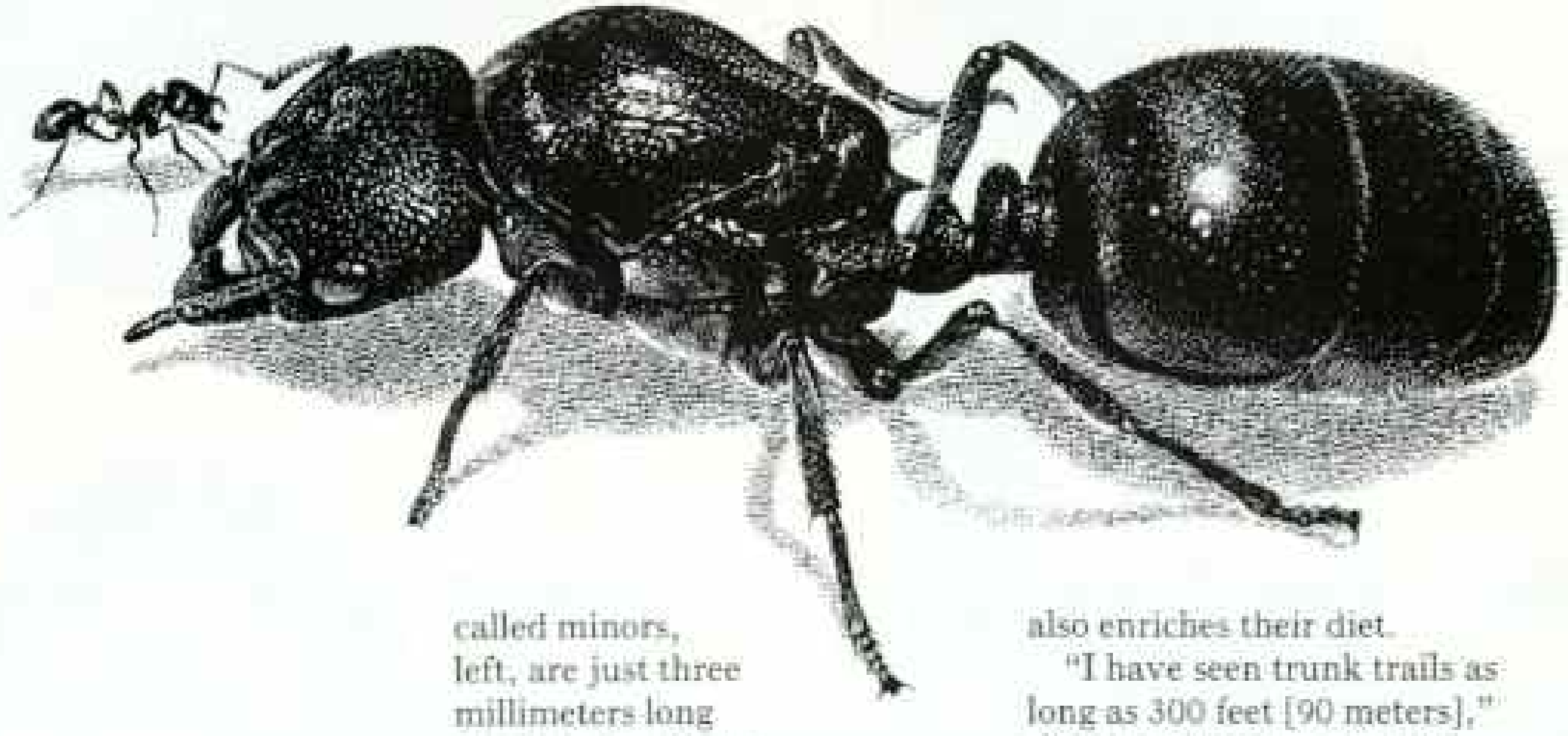
Marauder ants—the large and the small of it

Like some fairy-tale giantess towering over a diminutive Jack, an ant queen dwarfs a tiny worker. Both, amazingly, are from the same tropical Asian species, *Pheidologeton silenus*.

Exhibiting a trait known as polymorphism, this species and the closely related marauder ant *(P. diversus)* have evolved with different physical castes, each specializing in its own social tasks. Most of the workers,

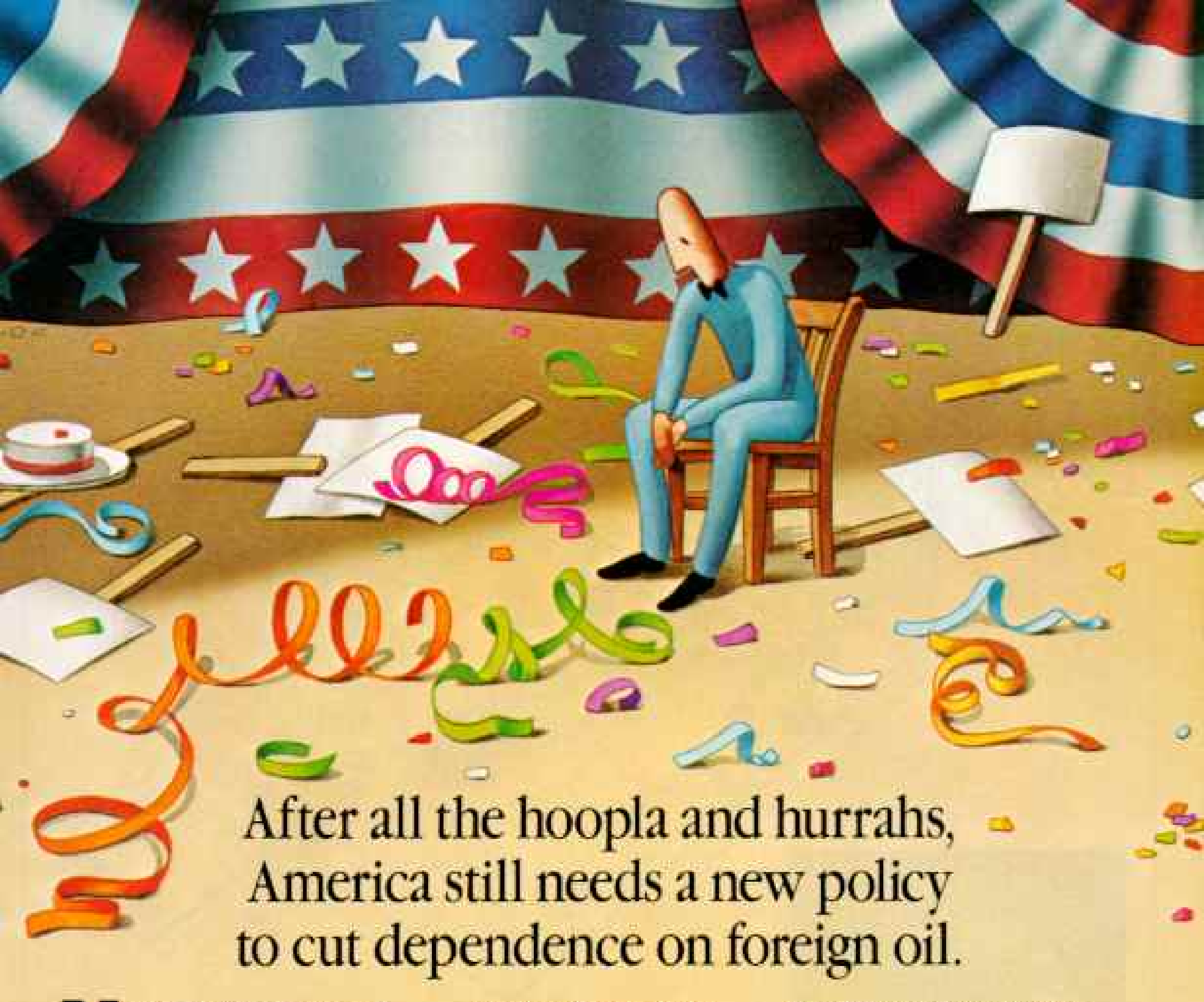


called minors, left, are just three millimeters long (a tenth of an inch). Some are intermediate-size workers called medias, and a few are ferocious-looking majors, armed with strong mandibles. The largest caste is the queen seen here. Her body weight can be a thousand times that of a minor.

The queen plays a privileged role in the all-female ant society. She alone is fertile; males exist only to fertilize her; then they die. All the workers in her realm are her daughters, who feed and tend her and her eggs constantly. She occasionally spawns new queens, who fly off to mate and start new colonies.

Marauder ants forage for food in an organized system that Napoleon would have envied. They carefully construct trunk trails up to three centimeters (an inch) wide. This is the artery through which all food flows to the nest. From these trails, tens of thousands of ants branch off in columns that can expand into fan-shaped raiding parties up to four meters across. Their prey—worms, centipedes, even frogs—are overwhelmed by sheer numbers and are crushed between the majors' powerful mandibles. Vegetable matter, mostly seeds, also enriches their diet.

"I have seen trunk trails as long as 300 feet [90 meters]," scientist Mark W. Moffett reported in the August 1986 NATIONAL GEOGRAPHIC. "Thousands of individuals seemed to merge into a single dynamic pattern. It was as if all the ants had united to form one great living creature. . . . Then this vision would dissolve, and the individuals would reappear, their labors finely coordinated, the different castes intricately apportioning the day's tasks."



After all the hoopla and hurrahs, America still needs a new policy to cut dependence on foreign oil.

Now that the election is over, we need a new national energy policy to encourage the development of proven alternatives to foreign oil, alternatives such as nuclear energy. A sudden oil embargo today would devastate our economy and threaten our national security.

America is using more and more foreign oil. We will soon be importing nearly 50 percent of all the oil we use.

We need a balanced national energy policy that will stimulate the use of alternatives to the growing threat of foreign oil. These alternatives must enable America to use energy more efficiently, invigorate our economic growth, supply our growing electricity needs, protect our environment, and reduce our dangerous dependence on foreign oil.

Nuclear Energy Cuts Oil Imports

Nuclear energy plays a major role in meeting all the requirements of a balanced energy policy. By making electricity with nuclear energy instead of oil, America's 109 nuclear power plants have already saved over 3 billion barrels of oil and over $100 billion in foreign oil payments. The savings will continue over the life of these plants. And new nuclear plants can supply the electricity our economy needs to grow—if we develop a new energy policy.

New Policy Needed

National issues require a national policy. But America's current energy policy is often decided on a short-term, state-by-state, case-by-case basis. This inconsistent approach and regulatory uncertainties at the federal, state and local levels make it difficult to plan and invest in proven long-term energy sources. We must solve those problems. Countries like Japan and France already pursue a long-term national energy policy of decreased dependence on foreign oil through the development of alternatives like nuclear energy. America should do it too.

Now that the confetti has been thrown, the winners have been cheered, and the elections are over, it's time for America to carry out a national policy that puts our energy destiny back in our own hands.

For a free booklet on energy independence, write to the U.S. Council for Energy Awareness, P.O. Box 66103, Dept. PC04, Washington, D.C. 20035. Please allow 2-3 weeks for delivery.

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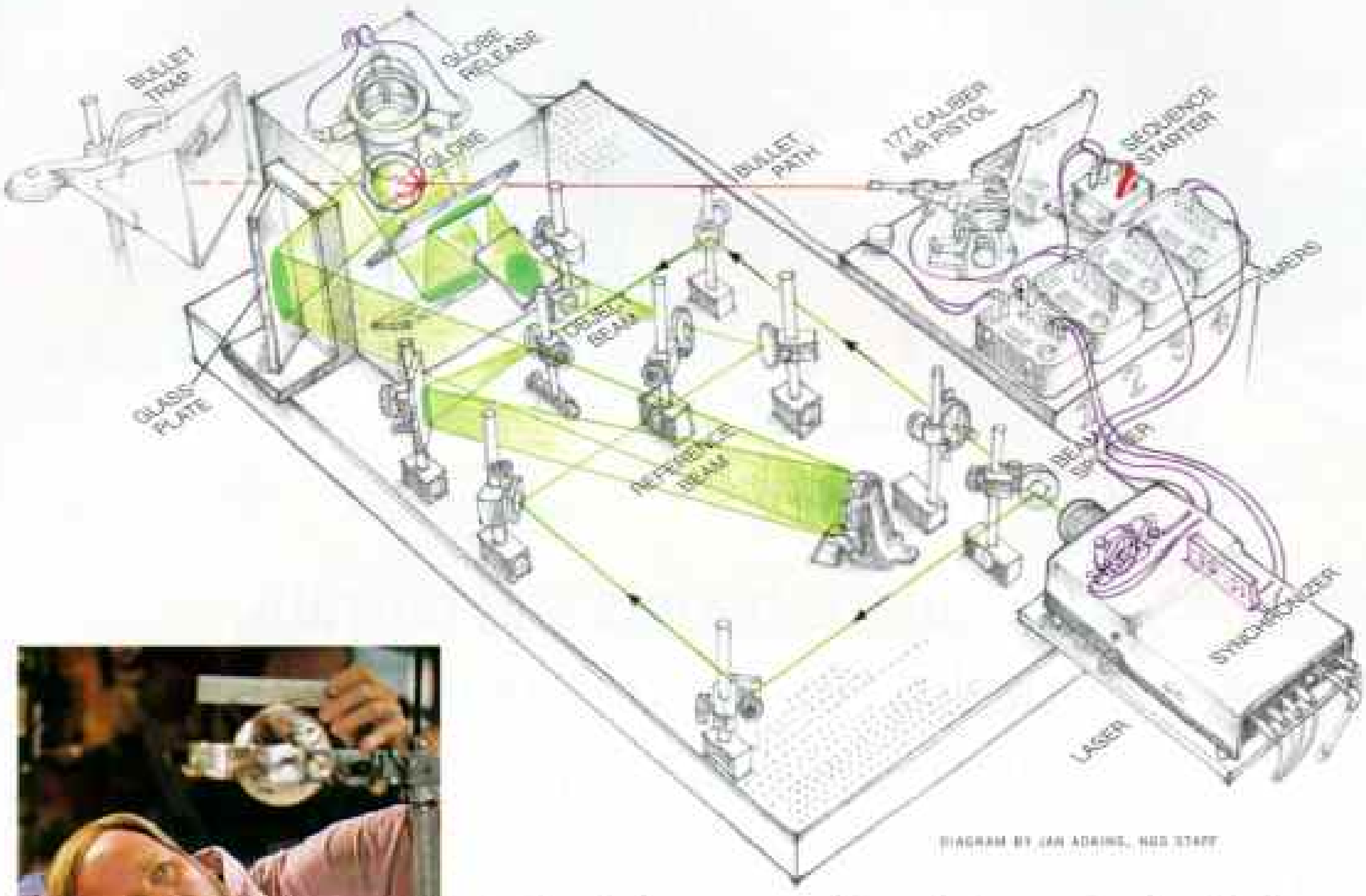

DIAGRAM BY JAN ADKINS, NGS STAFF

JOYCE DALE

A GREAT BONUS of being a Geographic photographer is the opportunity to specialize in subjects for long periods of time. During my 24 years on staff I've traveled with Gypsies, studied human cells, and ridden China's railroads (March 1988). Recently I helped Editor Bill Garrett realize his idea for this month's symbolic cover. His suggestion: Record a crystal globe as it breaks, shattering so continents are still recognizable. Produce the image as a double hologram of the globe before and after destruction. The GEOGRAPHIC had already published single-image holographic covers (March 1984 and November 1985).

Joining a team of scientific wizards from American Bank Note Holographics, Inc., I began my tests, filling two notebooks with a photographic record. To get the shattering effect without pulverizing the globe, I considered the effects of explosives, sound waves, freezing, and heat on inexpensive glass balls before selecting a nylon-clad pellet shot from a target air pistol. For a powerful light source we used a pulsed laser that worked like a strobe with a pulse duration of seven-billionths of a second at ten pulses per second. All action had to synchronize with that burst of light.

On a desktop computer I programmed variables such as the globe's size and pellet velocity to set four timers designed by my son Greg. Timer 1 dropped the globe as timer 2 fired the pistol. Timer 3 opened the laser's shutter, closed by number 4. The laser light was separated into an object beam that bounced off the globe onto a glass plate, and a reference beam that passed directly to the plate. The pattern of these two wave fronts of light formed a 3-D hologram of the breaking globe. Another hologram was made of a whole globe, and the two images were merged to create the "action" seen on the cover.

— BRUCE DALE

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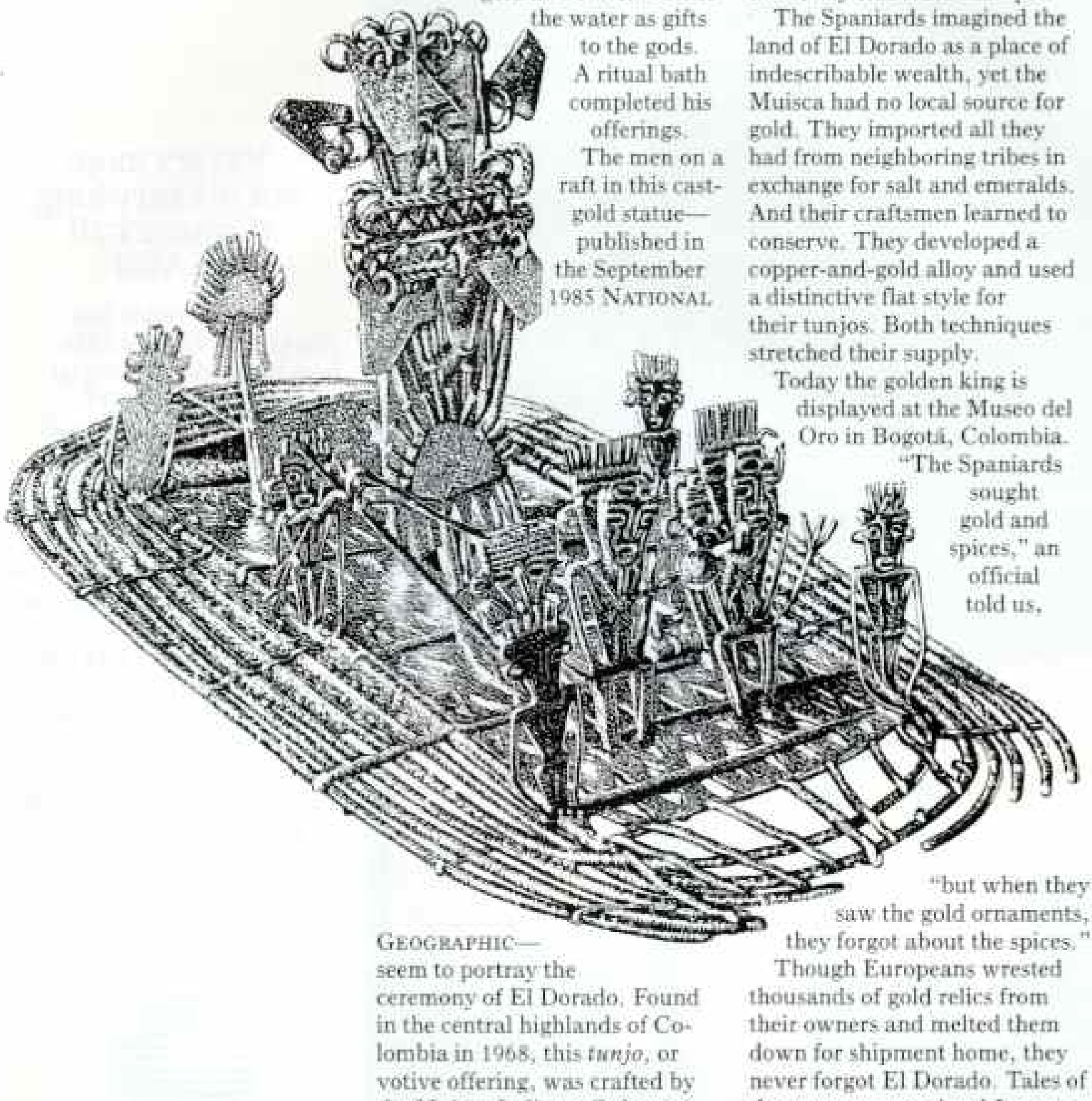
El Dorado: a golden king on a golden raft

Rumors of riches lured the Spanish conquistadores to penetrate South America in the 16th century, and riches they found. But the most storied prize remained the most elusive: the kingdom of El Dorado, "the gilded man."

Indian legend told of a sacred lake and a golden king. Anointed with resin and dusted with pure powdered gold, he would raft to the lake's center to hurl gold and emeralds into the water as gifts to the gods. A ritual bath completed his offerings.



The men on a raft in this cast-gold statue—published in the September 1985 NATIONAL GEOGRAPHIC—seem to portray the ceremony of El Dorado. Found in the central highlands of Colombia in 1968, this *tunjo*, or votive offering, was crafted by the Muisca Indians. Only 18.3 centimeters (7 inches) long, it displays exquisite detail from the king's high headdress to the tiny lashings of the reed raft. Craftsmen used lost-wax casting to form separate parts of the grouping, even the fine twining wire of the king's nose ornament.

Long before Spaniards arrived, Muisca goldsmiths were making tunjos depicting many aspects of Indian life, generally as single figures: a shaman, a coca-leaf chewer, a mother cradling her child. One tunjo represents a proud warrior, his club in one hand, a severed head in the other. The golden raft is an unusually elaborate example.

The Spaniards imagined the land of El Dorado as a place of indescribable wealth, yet the Muisca had no local source for gold. They imported all they had from neighboring tribes in exchange for salt and emeralds. And their craftsmen learned to conserve. They developed a copper-and-gold alloy and used a distinctive flat style for their tunjos. Both techniques stretched their supply.

Today the golden king is displayed at the Museo del Oro in Bogotá, Colombia. "The Spaniards sought gold and spices," an official told us, "but when they saw the gold ornaments, they forgot about the spices."

Though Europeans wrested thousands of gold relics from their owners and melted them down for shipment home, they never forgot El Dorado. Tales of the ceremony persisted for centuries, centering on Lake Guatavita near Bogotá. Guatavita was partially drained. Gold was found, but no great cache to match the fabled wealth of the legend.

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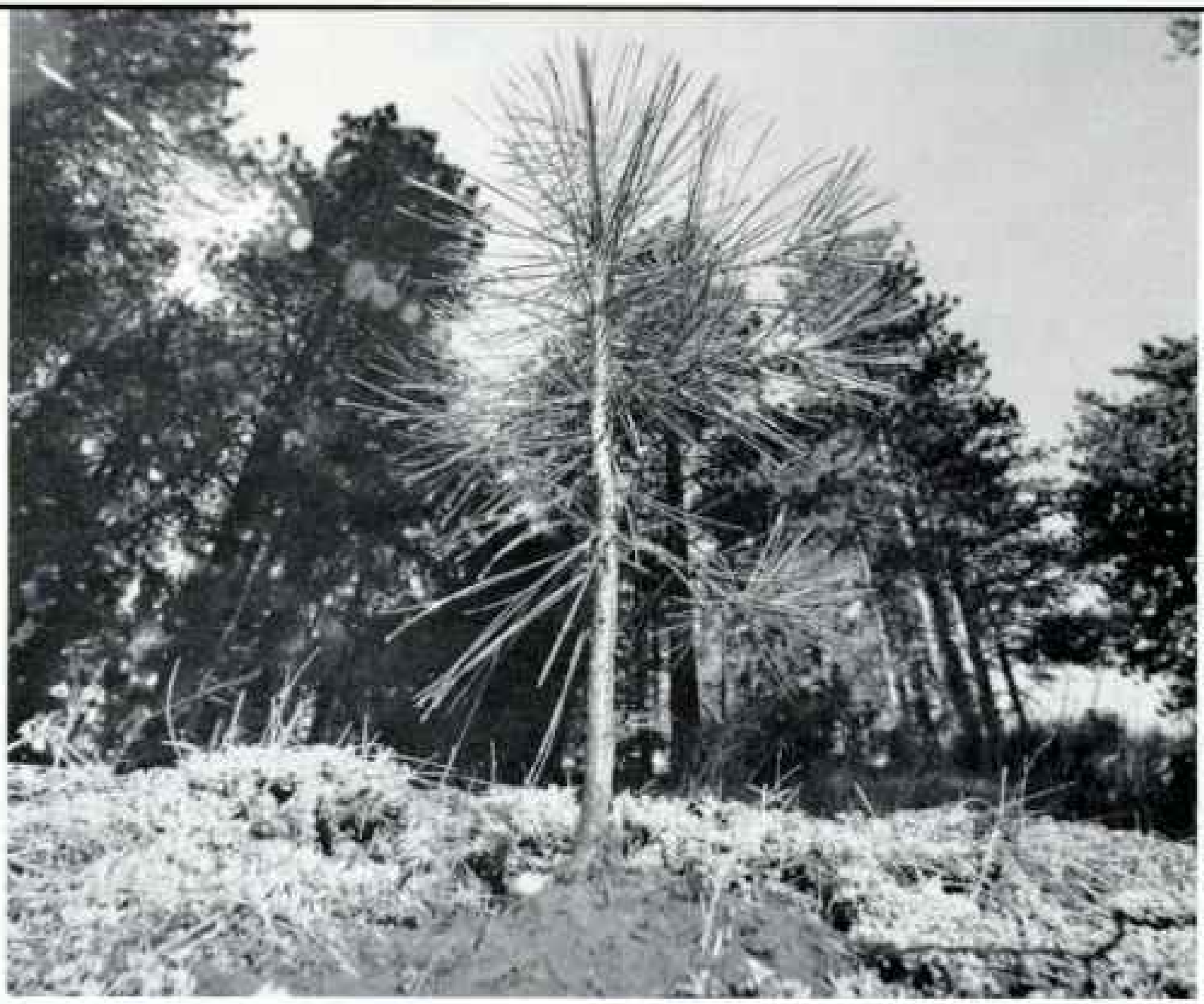

Miracle of the Forest

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Aye-Aye **Genus:** *Daubentonia* **Species:** *madagascariensis*
Adult size: Length of head and body, approx. 40cm; tail, approx. 40cm **Adult weight:** 3kg
Habitat: Rain forests of Madagascar **Surviving number:** Unknown
Photographed by Frans Lanting

Wildlife as Canon sees it

One of the greatest roles of photography is to record and preserve images of the world around us worthy to be handed down as a heritage for all generations. A photograph of the aye-aye offers a rare glimpse of one of Madagascar's most unique creatures facing extinction.

The solitary aye-aye sleeps by day in its leafy nest, emerging at night to search for food. The aye-aye's large, bat-like ears detect larvae hidden beneath the bark of trees. Its sharp incisors tear away the bark to expose the larvae, and can also penetrate the tough outer shell of coconut and other fruit. Perceived in extremes according to Madagascan folklore, this unusual lemur is feared by some as a harbinger of death, and revered by others. The aye-aye, like most of Madagascar's wildlife, is threatened by a loss of habitat.

As with most endangered species, the future of the aye-aye greatly depends on mankind's ability to live in harmony with the natural world. An invaluable research tool, photography can promote a better understanding and awareness of the aye-aye and how it lives within its natural environment.

And understanding is perhaps the single most important factor in saving the aye-aye and all of wildlife.