

What Will Be Their Fate?

Tropical Forests

by Hugh H. Iltis



The destruction of tropical forests in the world today is so extensive, so devastating, so irrevocable that humanity may soon lose its richest, most diverse, and most valuable biotic resource. As a consequence, life will lose forever much of its capability for continued evolution. Many groups of the larger vertebrates (mammals, birds, reptiles) will be especially affected, but countless other organisms—less spectacular insect, mollusk, and plant species—will be lost as well.¹ The economic, esthetic, and cultural losses to future generations will be incalculable.

The damage may not be visible to us here in the United States, for the tropics are faraway, hot and humid places about which we know very little and have been taught even less. To most people the word "tropics" itself conjures up a picture of pristine

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nature, mysterious and marvelous; of great apes and elephants, of orchids and palms.

Precisely because the tropics *are* mysterious and wonderful, it has been hard to escape the nineteenth-century colonial mentality of a wild and green El Dorado just waiting to

be explored in a dugout canoe: a tropical last frontier with unlimited riches still begging to be "developed" by enterprising pioneers (now, of course, ostensibly for the benefit of native populations).² The horrendous destruction of nature over the past half century—the critical reason for

the now-widespread concern among biologists—was almost always conveniently ignored or belittled. The realistic ecological picture today, however, and its long-range implications are very grim indeed.

Those of us who take pride in being environmentally enlightened have been teaching pollution control and contour plowing, nature preservation and Aldo Leopold's land ethic, but mostly with reference to our own rather impoverished temperate biota.³ What little concern we may have had for the tropics was rarely based on reality. In our comfortable ignorance, these lush lands and their wild animals seemed so safe from destruction that we rarely worried about their fate. The underdevelopment, the innocence of their illiterate populations, and the endemic tropical plagues like malaria and yellow fever that kept their populations well in check seemed sure to offer their ample protection.

Since 1945, however, all this has changed. We now have DDT and 2,4,5-T; the all-powerful (and greedy) multinational corporations with their woodchippers and jungle smashers (one acre an hour, as advertised by Le Tourneau); the vast and hungry army of the poor and the landless; and the devastating, self-serving, post-World War II development syndrome.

Inevitably, what has resulted from these activities has been the systematic, barbaric obliteration of nature for the "benefit of man." As a consequence, we are faced today with the greatest biological calamity this world has ever known—the imminent decimation and extermination of the world's tropical biota. As E.O. Wilson put it, such a great loss of genetic diversity would be worse than

*energy depletion, economic collapse, limited nuclear war or conquest by a totalitarian government. [In fact,] [a]s terrible as those catastrophes would be for us, they could be repaired within a few generations The one process ongoing in the 1980s that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us.*⁴

Tropical Destruction

It is in the tropics, in particular in their inconceivably diverse and beautiful but fragile wet forests, that biological genocide is in full swing. Of the estimated 8 (to possibly 30) million species of plants and animals on Earth, a vast preponderance live in tropical ecosystems. The destruction of such habitats, therefore, would bring in its wake the extermination of literally millions of species—species of which, for the most part, we do not yet have a description, a picture, a life history, or even a name.

Indeed, the utter devastation that humanity is now bringing to tropical ecosystems—the vast and uncontrolled forest destruction in many regions of Asia, Australia, Africa, and Latin America—has to be seen to be believed. During 1962, at the foothills of the Andes in a Peruvian valley near San Ramon, I stood on a narrow hanging bridge suspended over a clear mountain stream and watched a troop of spider monkeys, a hundred feet up, jumping from one tree to the next and eating fruits from a gigantic fig tree. Iridescent blue, giant *Morpho* butterflies sailed erratically through a sun-flecked opening in the forest, while a pair of banana-billed toucans sat motionless on a branch silently watching—a scene seemingly straight out of Genesis.

Today, none of this exists, for later that year, with a development grant provided by the U.S.-sponsored "Alianza para el Progreso," an energetic man bought the land (and presumably all the Indians living on it), cut down the forest, and planted coffee and bananas on its 45-degree slopes. Such land clearing is now widespread all over the Andes, and has resulted in massive soil erosion, siltation of rivers, and even climatic changes. The dramatic and unprecedented fluctuations in recent Amazonian water levels⁵ are among the serious and unexpected consequences. Loss of species is another.

With such extensive habitat destruction, it is small wonder that all

around the world primates, along with many of the larger vertebrates, are facing extinction. In three months of South American field work in 1977, we saw only *one* spider monkey—a pet on a silver chain in a hotel lobby.

That was in Ecuador, where we visited the lowlands of the Pacific slope. The forests there, separated from those of the Amazon basin by the lofty peaks of the Andes, are the home of several thousand unique local species (termed endemics) that evolved here in isolation, providing fascinating examples of geographic speciation.

Near Santo Domingo de los Colorados lies a small remnant of moist tropical forest, studied intensively by Calloway Dodson and Alwyn Gentry. As described in their *Flora of Rio Palenque*,⁶ this tract of only 167 hectares (circa 420 acres) has over 1,100 species of plants in 123 families. Almost half of them are woody. Nearly 6 percent of them were new to science, and 4 percent are endemics, known to be from nowhere else on earth.

A small "sierra" only three miles away has strikingly different and also highly endemic flora, a diversity quite unexpected by any temperate-zone botanist. But in the tropics, whether in Panama, Mexico, Colombia, Borneo, or here in Ecuador, local floras are saturated with unique taxa: local endemism is the rule, widespread species the exception.

For example, in Ecuador—a country no bigger than Minnesota—there may well be as many as 20,000 different species of plants, over one-fifth of them endemic. On the other hand, there are only around 17,000 plant species in all of North America, and only 1,700 native species in all of Minnesota, which, at best, can boast of only one endemic—a semi-sterile Dogtooth Violet (*Erythronium pro-pullans*) perhaps of hybrid origin.

Because of this overwhelming biotic diversity and the briefness of their acquaintance with it, biologists remain quite ignorant of most tropical species (especially insects) and

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their interrelations. How very much we have yet to learn is evidenced by the fact that one-fourth of the neotropical wet-forest plant species and more than nine-tenths of its animal species are still unknown to science.

Rio Palenque is a mere 400 acres of wild nature, yet it is the only preserved remnant of this particular type of tropical forest on the whole of the Pacific slope of Ecuador. It is now but a tiny island of virgin forest complexity set in a vast sea of sterile, cultivated uniformity—thousands of square miles of monocultured bananas, sugar cane, African oil palms, and corn.

What only 25 years ago was the most inaccessible and unknown of tropical forests—a dream for any botanical explorer, stretching uninterrupted from Quevedo to Esmeraldas—and a region from which hardly any biological specimens were available for scientific study, has now been almost totally destroyed. Only an occasional plank-rooted forest

giant, uncut because of its immense size, stands alone in a field of bananas. It is a pathetic, grim reminder that now we shall never know what botanical or zoological riches these forests once held. In many ways it is already too late for their study.

Spreading Development

This picture of tropical forest “conversion,” of century-old giants being felled and mountains of bulldozed primeval wilderness being burned to give way to cow pastures, corn fields, and tree plantations to provide food and firewood for the hungry, is being repeated again and again—in Brazil, in Panama, in Indonesia, and in Mexico.⁷ The U.N. Food and Agriculture Organization (FAO) estimates that 7.5 million hectares of closed forest and 3.8 million hectares of open forest are currently being destroyed *each year*.⁸ At this rate, it will be all over in 20 years.

Even the seasonally dry forests now are getting the axe. I cannot tell you with what feelings of horror and hopelessness I witnessed the bulldozing of a hundred-thousand-acre plot of virgin tropical-dry forest in the coastal plain of southwestern Mexico. These arid lands supported 40-foot tall “candelabra” cacti and an army of small trees, yet they are essentially useless for agriculture because of very low rainfall. Does a miserable crop of sorghum for cattle feed every three or four years justify so mindless a destruction?⁹

Nearby, in the moist oak-fir-pine forests of the 10,000-foot Sierra de Manantlán, we discovered three years ago a wild perennial grass (*Zea diploperennis*) that is ancestral to corn and of immense economic potential.¹⁰ Today, lumber trucks still continue to roar down these mountains every half-hour, hauling gigantic logs to be made into boards and into broom handles that are exported to the United States in order to gain badly needed foreign exchange. The trucks are witnesses to the steady, if slow, devastation of a biological

treasure-house.¹¹ If the encroaching agricultural development had reached the minuscule habitats of *Zea diploperennis*, a dozen cows in a week's time could have obliterated this species, and with it the possibility of ever developing highly virus-resistant or even perennial corn.¹²

For many of us in North America, the destruction of these Latin American habitats has another, more special significance. The migratory birds we love to see in the summer depend on wild places in Latin America to survive the winter. Warblers in the Ohio Valley already are becoming rarer. Farmers and orchard owners depend upon these birds to a considerable degree for insect control. Many of our larger birds are moving closer to extinction year by year. From both the standpoint of the birds' survival and our own, this is indeed “one world.”¹³

Bioclimactic Paradox

Many well-meaning American advisors and humanitarians have been misled by the luxuriance of the tropical forests. How many times have they announced that the answer to world hunger lies in their sustained agricultural utilization? Yet, ignorance of ecology in this case is fatal.

As Professor J. Chang¹⁴ of the University of Hawaii has explained, in the tropical regions, despite their lushness, annual grasses such as wheat, rye, barley, and rice have relatively low agricultural productivity compared to those species found in the cool temperate climates from whence they originally came. This is due to a simple bioclimatic fact: during the long and warm tropical nights, a plant's respiration burns up most of the surplus carbohydrates that it produces during the relatively short photosynthetic day. The 16-hour days followed by cool, 8-hour nights, as found in the Dakotas or the Ukraine, permit much greater accumulations of photosynthate in such plants, creating a bumper crop come harvest time.

In addition, high rainfall tends to

leach the already nutrient-poor lateritic soils to sterile gravels in many parts of the lowland tropics, and there are no climatic controls (i.e., the freezing temperatures of winter) to knock back insect pests. Dreams of making bread baskets out of these regions evaporate into the fantasies that they are—editorials and lead articles in prominent journals notwithstanding.¹⁵

Thus, the tropics—the wet tropics in particular—present a climatically determined paradox. Biologically, they are rich beyond belief, but in many significant ways they are agriculturally quite poor. That Iowa or South Dakota can never become a Mexico, Panama, or Amazonian Brazil in terms of biological diversity seems obvious. At the same time, tropical countries can never become an Iowa or a South Dakota in terms of agricultural productivity. This ecological fact will have serious political consequences and will be unpleasant to face.

There is another side to this great productivity-diversity-preservation paradox: the countries most desperately in need of money to create and maintain the gigantic national parks necessary to preserve their unique biological riches—both for themselves and for the whole world—are the very ones that are usually too poor to afford them. Statistics on park personnel bear this out. Compared to the tropical nations, the industrialized countries spend ten times the money and support ten times the staff per unit area of park.

Thus, the countries with so much to preserve can, in their poverty, preserve only a little. Just think of the incredible collection of large game animals that now crowd the remaining central African savannas and forests: rhinos, lions, gazelles, and giraffes—all residents of poor countries that have disastrous economies and exploding populations. Yet, the Serengeti is still a park. Worldwide, even despite great handicaps, countries small and large make valiant efforts (often with assistance from the World Wildlife Fund) to preserve

their patrimony of wildlife and diversity.

A bright light amid all this destruction is the massive effort by a variety of people in Latin America to preserve the tropical biota within their countries.¹⁶ Costa Rica has a national system of 22 well-administered parks and reserves, which, considering the small size of the country, is unrivaled by any other in Latin America.¹⁷ In fact, 8 percent of its area is under effective protection, and Costa Rica's per capita financial commitment to its parks is higher than that of the United States.

Significant advances have been made in the Amazonian regions of Bolivia, Brazil, Ecuador, and Venezuela, where, during the past 16 years, nearly 12 million hectares of forest have been placed under protection.¹⁸ Admittedly, most of these are as yet unstaffed and exist "on paper only." Nevertheless, even this is a first step, and recognition must be given to the many forces in Latin America working for preservation. They should be encouraged to continue these efforts.

An Ironic Lesson

In addition, it may be wise to consider the proposal by Ira Rubinoff, director of the Smithsonian Tropical Research Institute, for a global system of protected tropical forest preserves that would be supported by the international community through taxation of all countries whose people enjoy a per capita income greater than \$1,500 a year. It should be remembered that developed nations have an economic stake in the survival of tropical forests at least as great as, or greater than, the nations in which the forests grow.¹⁹ One percent of our bloated defense budget would go a long way toward setting aside 1,000 preserves of 600,000 acres (240,000 hectares) each, which would insure the preservation of approximately 10 percent of the rain forests (only 2 percent are now so protected).

For Americans, there is an ironic lesson in the loss of the tropical biota,

for what Latin American countries in particular are unable or unwilling to preserve will haunt us in the centuries to come. It is not only the songbirds that we shall miss. The rich, overdeveloped nations have long used their economic clout to exploit mercilessly the poor, underdeveloped tropical nations, and directly—or indirectly—have added the insult to injury of abusing their biological treasures.

Politicians or businessmen are hardly ever interested in the preservation of rare Brazilian reptiles or Mexican birds, or in the percentage of endemics in the Colombian biota. The decisions they make concerning the fate of this bountiful life are almost always in terms of short-range profit, not long-range wisdom. Just ask the American lumber companies, or the gigantic Japanese concerns that are (literally) ripping off the forest resources of Southeast Asia and the "living museum" of New Guinea.

But this is one world, and the catastrophic loss of wildlife will affect us all. Our children and theirs may well wish to study the tropics, will want to see them for themselves, and, at the very least, will want access to the vast storehouse of economic plants and animals that these forests contain²⁰ and the opportunity to study the important ecological phenomena that they exhibit. If we are to keep faith with our children, the overdeveloped nations must learn, now and quickly, as an integral part of their foreign policy and foreign aid, to approach the problem of extinction seriously and in a new and much more far-sighted, financially responsible way. Establishment of an enlightened foreign policy depends on efforts to subsidize the staffing and upkeep of preservation efforts in the tropics, to help train biologists, to build local museums of natural history, and to translate or otherwise make available the scientific literature so that people of these areas can become experts of their own biota.²¹

The trend, of course, has been the other way. We have persisted in our political and economic domination of

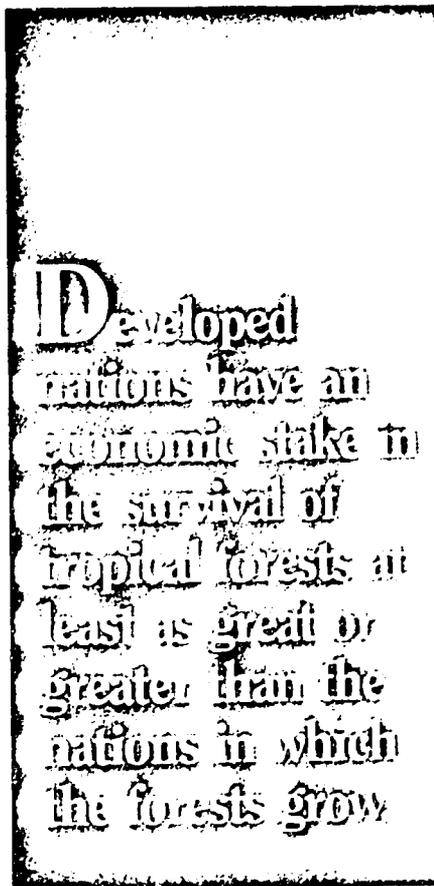
the tropics. Furthermore, the biologically ignorant leaders of the overdeveloped nations have continually beaten the drum for rapid "sustainable development" of the tropics, unmindful that the tropical forests cannot be exploited on a permanent basis without destroying them.²²

Try as these countries may, saddled as they are with their burgeoning populations, they will simply never be able to reach a high level of wealth unless they happen to own oil wells. But in the process of a biologically insensitive "development," they will surely destroy their own biotic wealth.

There is both hypocrisy and tragedy here: hypocrisy because these geographic-economic factors are well known but too inconvenient to be accepted, and tragedy because what all the underdeveloped countries need now more than anything else are freely available and medically safe population control measures on the one hand, and peace and freedom from economic manipulation and exploitation by the overdeveloped countries on the other. On both of these counts, the United States, the only country we ourselves can hope to influence directly, is unfortunately ambiguous, vacillating, and self-serving.

Educating the Public

In the meantime, preservation fails by the wayside, exploitation of the tropical forests and their conversion to hamburger-producing cow pastures continues unabated,²³ and extermination and extinction of species are occurring at a wholesale rate, now claiming perhaps many thousands of species each year.²⁴ To a considerable extent, the tone has been set by rapacious multinational and national corporations based in the United States, Japan, and Europe—something that we need to be aware of, something that we must, with dedication and courage, try to correct within this decade. No small part of this will be the education of the American, European, and Japanese public.



Developed nations have an economic stake in the survival of tropical forests at least as great or greater than the nations in which the forests grow

That the forces opposing a rational solution to these ecological problems are all-powerful and influential need hardly be pointed out. In 1970, we had Earth Days from coast to coast, dedicating ourselves to a biologically sane world. Now, 13 years later, this profound intellectual revolution is all but dead, sabotaged by administrative officials and by heavily subsidized and carefully orchestrated campaigns of the media and their corporate allies, which have obscured the very real dangers in neglecting the world's ecology.

I need only to point out that the special anniversary issue of *Time* magazine, "The Most Amazing 60 Years in History," published October 5, 1983, does not mention or illustrate in its 168 pages of text and lavish pictures one *single* environmental event, fact, or problem: *nothing* whatever on Earth Day or Rachel Carson's *Silent Spring* or on DDT or 2,4,5-T, or on extinction of species or pollution, or soil erosion; in fact, absolutely not one word on *any* environmental issue.

This indifference to reality reaches even to *Time's* total silence on the population explosion. This is, on reflection, surely the most terrifying fact of the past 60 years: the near tripling of the world's population,²⁵ an increase of fully 2.95 billion additional people since 1923, the year when *Time* magazine came into existence.

This brings me to a final point. While corporations exploit and their political bedfellows run interference for dubious economic aims, let us not forget (well-meaning liberals included) that equally responsible for these biological extinctions are poverty, hunger, and ignorance—the chop-chop of a million axes, the cravings of a billion mouths.

Although the people of the tropics do need more protein and more firewood, they need birth control even more. For by now, any knowledgeable observer of the world's scene must come to the conclusion that the *food vs. population* race can never be won—or rather, can only be won by decreasing the birth rate by whatever means of birth control are available. It certainly will not be won by furthering the immaculate misconceptions of raising more food by cutting down more forests, by plowing up more prairies, and by draining more wetlands.²⁶ We are running out of all of these, and the population bomb keeps on ticking.

The world's net population increase in 1982 was 82 million people,²⁷ the highest *yearly* increase ever—and mostly in the tropics. (An estimated 40 to 50 million abortions allowed that many additional children *not* to be born.) Only in an ecologically educated world public, in nations self-restrained in both resource use and reproduction, is there any hope for the conjunction of a healthy and well-fed population, a biotically rich earth, and peaceful co-existence.

We must impress on our students these facts: that the world's carrying capacity is finite, that there are too many people now, that the actual, very real collision between resources

(including food supply, clean living space, and tropical forests) and populations is the biggest, most fundamental, and most nearly insoluble problem that has ever confronted the human race. Whether wild ecosystems of any sort will long survive (even in the United States) will depend upon its resolution. The outlook is not hopeful. Men and women of good will have no alternative but to work for the preservation of a nature-rich good earth. ■

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NOTES

1. Anonymous, *The World's Tropical Forests: A Policy, Strategy and Program for the United States* (Washington, D.C.: U.S. Government Printing Office, 1980); G.O. Barney (study director), *The Global 2000 Report to the President: Entering the Twenty-first Century* (Washington, D.C.: U.S. GPO, 1980); D.W. Ehrerfeld, *Conserving Life on Earth* (New York: Oxford University Press, 1972); P. Ehrlich and A. Ehrlich, *Extinction: The Causes and Consequences of the Disappearance of Species* (New York: Random House, 1981); A. Gomez-Pompa, C. Vasquez-Yanes, and S. Guevara, "The Tropical Rain Forest: A Nonrenewable Resource," *Science* 177(1972): 762-765; H. H. Iltis, "Shepherds Leading Sheep to Slaughter—The Biology Teacher and Man's Mad and Final War on Nature," *The American Biology Teacher* 34(1972):127-130, 137, 201-205, 221; H.H. Iltis, "To the Taxonomist and Ecologist: Whose Fight is the Preservation of Nature?" *BioScience* 17(1967): 886-890; N. Myers, *The Sinking Ark* (Oxford: Pergamon Press, 1979); N. Myers, *Conversion of Tropical Moist Forests* (Washington, D.C.: National Academy of Sciences Press, 1980); National Research Council, Committee on Research Priorities in Tropical Biology, *Research Priorities in Tropical Biology* (Washington, D.C.: National Academy of Sciences Press, 1980); G.F. Prance and T.S. Elias eds., *Extinction Is Forever* (Bronx, N.Y.: The New York Botanical Garden, 1977); P.H. Raven, "Tropical Rain Forests: A Global Responsibility," *Natural History* 90(1981):28-32.
2. For pro-development appraisals of Amazonian colonization, see Tad Szulc, "Pioneers Carve a New Frontier—Will the Next Century Belong to Brazil?" *Parade Magazine*, September 4, 1983, pp. 4-6. This article contains an economic justification and humanistic glorification of biological destruction, and reached perhaps 30 million or more American households; see also P. H. Abelson's editorial, "Rain Forests of Amazonia," *Science* 221 (1983): 507. Equally uncritical is this tragic view of Amazonia by a prominent American businessman-diplomat: "The cause of this discouraging rate of development [of the Amazonian rain forest] is that the ground itself must first be cleared of jungle . . . and civilization itself introduced, before new farms can be laid out and made productive. . . . Whole new traditions and ways of life must be established Just to look at the geography is to see the formidable nature of the challenge. One huge belt of land . . . lies on the equator in the heart of the heat and fevers of the tropics. The Amazon River, unlike the Mississippi, flows through vast tracks of what are silt sodden, malaria-ridden, impenetrable jungle wastelands, its waters patrolled by alligators and man-eating snakes. In contrast, the gentle, traffic-moving rivers of Europe have been channels of trade for a thousand years." S.L. Linowitz, "The Future of the Americas," *Science* 181(1973): 916-920.
3. The former pre-occupation with the preservation of local plant communities is shown by M.L. Fernald of Harvard University in his famous pioneering essay, "Must all Rare Plants Suffer the Fate of Franklinia?" *Journal of the Franklin Institute* 226(1938): 383-397.
4. E.O. Wilson, as quoted in P. Schabecoff, "A Million Species Are Endangered," *New York Times* November 22, 1981; cf. *Proceedings of the U.S. Strategy Conference on Biological Diversity* (Washington, D.C.: Department of State, 1982).
5. A.H. Gentry and J. Lopez-Parodi, "Deforestation and Increased Flooding of the Upper Amazon," *Science* 210 (1980): 1354-1356; I. Friedman, "The Amazon Basin, Another Sahel?" *Science* 197(1977): 7.
6. C.H. Dodson and A.H. Gentry, "Flora of the Rio Palenque Science Center," *Selbyana* 4(1978):1-628.
7. J.D. Nations and D.I. Komer, "Rainforests and the Hamburger Society," *Environment* 25(1983):12-20; see also note 1 above.
8. P.M. Fearnside, "Deforestation in the Brazilian Amazon: How Fast Is It Occurring?" *Interciencia* 7(1982): 82-88; the utilitarian, anti-preservation opposition creates the impression that there are no hard data on tropical deforestation, that environmentalists (such as N. Myers) exaggerate the extent of damage [e.g., the Lugo-Brown critique of Myers' book in *Interciencia* 7(1982): 89-93], and that, since there is nothing really to worry about, scientists and preservationists are misleading the public. But "it is irrelevant in the long range, whether the proportion of forests destroyed is 0.6% or 2% of the biome per year" [N. Myers, *Interciencia* (1982)7:358], whether 60,000 km² or 200,000 km² of primary virgin forest are converted to permanent cultivation each year, because even the lower figure is an incredibly large area—1/3 as large as the state of Wisconsin. In either case, it represents ecological insanity. Sad to note, in the eyes of the world's power brokers, nature destruction is always justified, if by doing so people get fed and hunger is alleviated. The crucial, ultimate question, "what are we going to do then?" after three or four decades, once everything is gone and the world will be even fuller with people than now, is conveniently neglected.
9. D. Poore, "Deforestation and the Population Factor," *IUCN Bulletin*, January-February-March 1983; reprinted in *Parks* 8(1983):11-12.
10. H.H. Iltis et al., "*Zea diploperennis* (Gramineae): A New Teosinte from Mexico," *Science* 203(1979): 186-187; N.D. Vietmeyer, "A Wild Relative May Give Corn Perennial Genes," *Smithsonian* 10(1979): 68-75; L.R. Nault et al., "Response of Annual and Perennial Teosintes (*Zea*) to Six Maize Viruses," *Plant Disease* 66(1982): 61-62; and L.R. Nault and W.R. Findley, "*Zea diploperennis*: A Primitive Relative Offers New Traits to Improve Corn," *Desert Plants* 3(1982): 203-205.
11. There are currently attempts being made by the Universidad de Guadalajara and the Instituto Nacional de Investigaciones Sobre Recursos Bioticos (INIREB), Xalapa, to set aside part of this magnificent mountain range as a scientific preserve.
12. See note 10 above.
13. B. Webster, "Songbirds Decline in America," *New York Times*, August 12, 1980; J.W. Fitzpatrick, "Northern Birds at Home in the Neotropics," *Natural History* 91(1982): 40-47.
14. J. Chang, "Potential Photosynthesis and Crop Productivity," *Annals of the Assn. of Amer. Geographers* 60(1970): 92-101; D.M. Gates, "The Flow of Energy in the Biosphere," *Scientific American* 224(1971): 88-100. At the same time, the quite effective agricultural methodologies evolved by primitive or indigenous peoples in the Amazon and elsewhere are also in need of deliberate protection. They can teach us a great deal about how forests can be utilized to some extent and with minimum impact on ecosystem function. But, just like the tropical forests themselves, the life, knowledge, and culture of these forest farmers are being destroyed.
15. See note 2 above.
16. W. M. Denevan, "Latin America," in G.A. Kless, ed., *World Systems of Traditional Resource Management* (N.Y.: Halstead Press, 1980), pp. 217-244; P.M. Fearnside, "Development Alternatives in the Brazilian Amazon: An Ecological Evaluation," *Interciencia* 8(1983): 65-78.
17. D.H. Janzen, ed., *Costa Rican Natural History* (Chicago: University of Chicago Press, 1983); M.A. Boza and R. Mendoza, *The National Parks of Costa Rica*, published under the auspices of the Costa Rican Institute of Tourism, the National University, the National Park Service, and the National Open University (Madrid: INCAFO, 1981); and personal communication with Alvaro Ugalde, director of the Costa Rica National Parks Service and executive director of the Costa Rica National Parks Foundation, November 1983.
18. G.B. Wetterberg, G.T. Prance, and T.E. Lovejoy, "Conservation Progress in Amazonia: A Structural Review," *Parks* 6(1981): 5-10; A. Gentry, "Extinction and Conservation of Plant Species in Tropical America. A Phytogeographical Perspective," in I. Hedberg ed., *Systematic Botany, Plant Utilization and Biosphere Conservation* (Stockholm: Almqvist and Wiksell, 1979).
19. J.S. Denlow and T.C. Moermond, "Why We Must Save the Rain Forests," *Capital Times* (Madison, Wisconsin), August 28, 1982; I. Rubinoff, "A Strategy for Preserving Tropical Rainforests," *AMBIO* 12, no. 5(1983):255-258; and J. D. Nations and D. I. Komer, "Central America's Tropical Rainforests: Positive Steps for Survival," *AMBIO* 12, no. 5 (1983): 232-238.
20. N. Myers, *A Wealth of Wild Species* (Boulder, Colorado: Westview Press, 1983); G. Wilkes, "The World's Crop Plant Germplasm: An Endangered Resource," *Bulletin of the Atomic Scientists* 33 (1977): 8-16; J.V. Neel, "Lessons from a Primitive People," *Science* 170(1970):815-822; and H. H. Iltis, "Discovery of No. 832: An Essay in Defense of the National Science Foundation," *Desert Plants* 3, no. 4 (June 1982): 175-192.
21. H.H. Iltis and D.A. Kolterman, "Botanical Translations: Needs and Responsibilities," *BioScience* 33(1983): 613.
22. M. Jacobs, "The Spirits of Bali," *IUCN Bulletin* 14(1983): 64-65.
23. Nations and Komer, note 7 above.
24. See note 1 above.
25. Anonymous, "World Growth-Rate Breaks Record," *Wisconsin State Journal*, August 31, 1977.
26. L.R. Brown, "World Population Growth, Soil Erosion, and Food Security," *Science* 214(1981): 995-1002. "We have now squarely to face this paradox We have increased human hunger by feeding the hungry. We have increased human suffering by healing the sick. We have increased human want by giving to the needy. It is almost impossible for us to face the fact that this is so. The truth comes as a shocking discovery, for we have all been brought up in the Christian tradition in which caring for the least of our brethren has been counted the highest virtue." Rev. Duncan Howlett, All Souls Church, Washington, D.C., December 6, 1969. [Quoted in *The Other Side*, The Environmental Fund Newsletter, Washington, D.C., September 1979].
27. "World Growth-Rate," note 25 above.