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The world's tropical rainforests are disappearing at the rate of about 7.3 million hectares a year. Unfortunately up to half the world's genetic diversity is concentrated on only 6 percent of its land surface, mostly in tropical forests. If present trends are not reversed, humankind may witness the elimination of one million out of the planet's 5–10 million plant and animal species by the end of this century. Photo: SIDA/E Thorning.

Genetic Resources in Jeopardy

BY NORMAN MYERS

The impending extinction of large numbers of species and the resulting decrease in genetic diversity are among the most serious threats to the future of the planet. Although other human impacts such as pollution may be reversed within a few generations, a loss of genetic diversity resulting from the disturbance of natural habitats will take millions of years to correct.

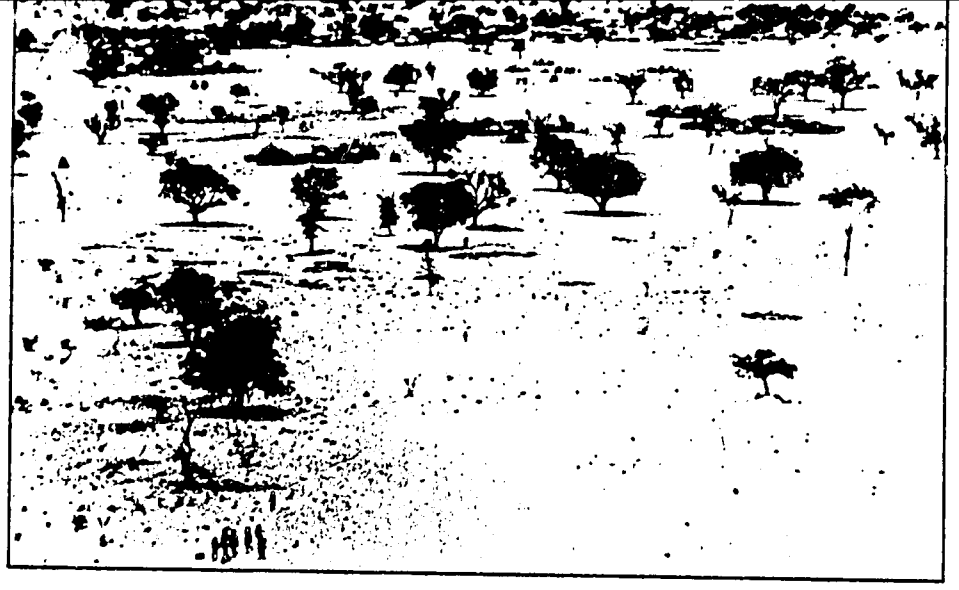
Humankind shares the planet with between five and ten million other species (1). Some recent research even suggests that there could be 30 million insect species in tropical forests alone (2). Whatever the true figure, these species represent a vast genetic reservoir available to support human welfare.

Through their genetic resources, these species provide essential materials for agriculture, medicine, industry, energy and other economic uses (3). The potential for further application has only begun to be explored. Scientists have made cursory appraisal of only one plant species in ten; and intensive analysis of only one in 100 out of a total of 250,000 plant species. As for the animal world, they have hardly made a start on evaluation. Considering the manifold benefits that we already enjoy, the genetic reservoir is among the most valuable natural resources with which we can confront the unknown challenges of the future.

The total number of species is not the standard by which genetic diversity should be judged. Virtually all species harbor a far greater amount of genetic variability than is suggested by the concept of species alone. A species comprises a number of subspecies, races and populations, each of which constitutes a distinctive reservoir of genetic material (4). Although intraspecies genetic differences are sometimes slight, they can often be markedly different. An idea of this "genetic plasticity" inherent in a species can be gained, for example, by considering the variability manifested in the many races of dogs or the many specialized types of corn developed by plant breeders.

PRESENT EXTINCTION RATE

At least two-thirds of all species occur in the tropics. These species tend to reveal greater genetic diversity than those elsewhere. Of tropical species, roughly two-



Subsistence agriculture, now practiced by some 600 million "poorest of the poor", may involve one billion by the beginning of the next century. Forced to destroy the resource base upon which they depend, these subsistence farmers contribute to the degradation of vast expanses of land as here in Niger. Photo: Mark Edwards/Earthscan.

thirds occur in tropical moist forests. In other words, more than two-fifths of all species exist in a biome that accounts for less than 10 million square kilometers—a mere seven percent of the earth's surface. These tropical forests are undergoing disruption and destruction at such rapid rates that it is reasonable to suppose that one species per day is being lost in these forests alone (5). Several other species-rich zones, notably coral reefs and wetlands, are also undergoing severe depletion.

By the end of this century we may well lose one million species in these biomes alone. This postulates an average rate of at least 100 species per day for the remainder of this century, with great waves of extinctions occurring during the latter part of the period as human population increases generate greater environmental impacts.

Many species are losing sub-units such as races and populations, at a rate that greatly reduces their genetic variability. Even though these species are not being endangered in terms of their overall numbers, they are undoubtedly suffering a decline in their genetic stocks. For example, the remaining gene pools of major crop plants such as corn and rice amount to only a fraction of the genetic diversity they harbored only a few decades ago, even though the species themselves are not threatened.

FUTURE RATES OF EXTINCTION

The extinction spasm that we should anticipate for the foreseeable future could well resemble, in terms of species numbers, the five great extinction episodes of the prehistoric past; and in terms of the compressed timescale involved, it seems likely to surpass any extinction episode since the emergence of life 3.6 billion years ago. When the dinosaurs and many of their contemporary species disappeared some 65 million years ago, their passing extended over several million years, whereas the present phenomenon appears likely to last little more than one century (6).

In contrast to the environmental damage caused, for example, by pollution or soil loss which may be reversed over the long run, a loss for species diversity represents an essentially irreversible process within relevant time scales. Judging by the recoveries following the "species crashes" which ended the Permian and Cretaceous Periods, it would take tens of millions of years to generate a complement of species comparable to that which exists today.

FACTORS OF EXTINCTION

Population Growth

The tropics, which host the greatest number and diversity of species, also lie within the developing world, where population is projected to be the greatest. Population growth however is not intrinsically threatening to species diversity. In populous countries such as Japan and the Netherlands, for example, urbanization has prevented widespread disruption of wildlife habitat. Developing countries, by contrast, will not achieve a parallel degree of urbanization even by the end of the next century. There will be huge numbers of people still living in rural areas and pursuing agricultural lifestyles.

By the end of the next century there will be three-fifths more people living in rural areas in the Third World than there are today. If they are forced to continue employing low-grade *extensive* agriculture, the tendency will be to spread to the farthest corners of what are now natural environments. If, on the other hand, they are able to practice efficient *intensive* agriculture they could make sustainably productive use of relatively limited sectors of their countries, with reduced impacts on wildlands.

But they will need technical inputs they can afford, and this, in turn, requires the full support of their governments. In short, the challenge is not only technological but political. As much attention must be paid to these broader perspectives of land use in the Third World, as to narrowly focussed campaigns to safeguard threatened species. To reiterate a familiar theme: conservation and development must operate hand in hand (7).

To visualize the prospect if most Third World farmers remain subsistence peasants, let us consider how things would work out for the United States if it were still a developing country. Instead of 80 percent of its 230 million people occupying only 2 percent of its territory, at least as many would be living off the land, and over-loading natural environments. Hordes of land-hungry peasants would be clamoring to occupy the country's parks and reserves, first the better-watered areas such as the Everglades (exceptionally rich in species), then the moderately-watered areas, and so on. How would the government be able to keep cattle herders out of Yosemite Valley, or timber cutters out of Yellowstone's forests?

By way of a real-world parallel, let us consider the prospect for Kenya, a country that has established an outstanding conservation record by setting aside six percent of its territory as parks and reserves in order to protect its wildlife and threatened species. Kenya's present population of 18 million people is pressing so hard on protected areas that the three leading conservation units are losing portions of territory to land hunger (8). Yet Kenya is projected to reach a total of 109 million people before its population growth stabilizes in the year 2115.

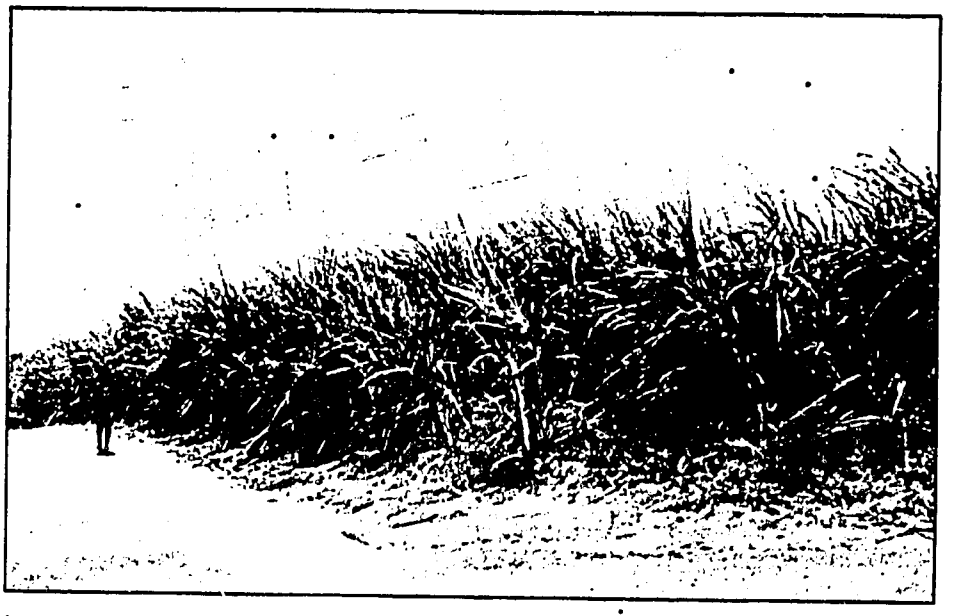
The prospects, then, for Kenya's parks are bleak. Similar population pressures threaten parks in Uganda, Ethiopia, Zimbabwe, and several other countries in which the impoverished peasantry is forced to draw from a dwindling resource base. Protected areas in these countries may be eliminated by the early part of the next century. Other countries such as Tanzania, Zambia, Mozambique, Sudan, Cameroon and at least one dozen other countries in Africa with valuable genetic resources will suffer severe pressures on their protected areas within the first quarter of the next century. The situation is particularly severe in sub-Saharan Africa because of the population growth rates, which are the highest in the world and are still increasing; and because of the increasing incidence of hunger, which forces rural agricultural communities to spread into hitherto undisturbed wildlands (9).

Poverty

Poverty reinforces the detrimental impact of population buildup. No person causes greater injury to natural environments than a hungry farmer. There are already 600 million of these "poorest of the poor", projected to reach at least one billion by the start of the next century and perhaps increasing to two billion by the time the developing world's population comes close to levelling out at around 10 billion in the year 2100 (10).

The subsistence peasant is often conscious of the fact that by altering soils, grasslands and forests he is jeopardizing the resource base which ideally should provide a livelihood for an indefinite period of time; yet the urgent food re-

One of the main causes of habitat destruction is agricultural expansion, often at the expense of sustainable resource management. Here a sugar cane crop in Kenya has replaced native species-rich vegetation. Photo: H Sjörs.



quirements of the short-term preclude any conservation measures.

Of course we can always hope for significant advances in agricultural technology, of a quality and scale enabling large numbers of farmers to practice improved forms of agriculture. But progress along these lines does not necessarily relieve the overall problem, insofar as enhanced agriculture for some does not inevitably lead to optimum patterns of land use overall. The Green Revolution now permits many farmers to make much better use of their croplands. But because of associated socioeconomic problems, the Green Revolution tends to "marginalize" the majority of less fortunate farmers, pushing them off traditional farmlands and into previously undisturbed marginal zones which are less suited to agriculture (11). Similarly, plantation agriculture, while making intensive use of croplands, often serves to leave multitudes of farmers landless (12). In Thailand, the Philippines, Indonesia, Brazil, Peru, Colombia, Kenya, Ivory Coast, Madagascar, and a string of other nations with unusual abundance of species, we can already observe a massive overflow of farmers from traditional homelands into virgin territories. These territories often include tropical forests, perceived by the migrant peasantry as "free" lands available for unimpeded settlement. They can also include woodlands, with their diverse wildlife, savannahs with their rich arrays of herbivores, montane zones with their concentrations of endemic species, and wetlands (both coastal and inland water bodies) with their unique communities of species.

Tropical moist forests, covering only 7 percent of Earth's land surface, harbor at least two-fifths of all species. Many of these species are unusually susceptible to summary extinction. At least one in ten enjoys only limited distribution (*ie* is endemic). In a single patch of montane forest in the Taita Hills of Kenya, more than 50 insects known nowhere else have been discovered. Many other species feature extreme ecological specializations, notably their integration with complex food webs and communities, which makes them vulnerable to even moderate disruption of their life-support systems. When these species are eliminated their passing tends to precipitate a process of "linked extinctions", with "shatter effects" throughout their ecosystems (13).

Consumerism

Besides the subsistence farmer, the agent who is next most capable of environmental destruction is the person at the other end of the "welfare scale": the super-affluent [illegible] who seeks more goods at "fair" [illegible]. Communities in North America, concerned about increases in the cost of beef, foster, albeit unwittingly, the deforestation of Central America in order to supply ostensibly cheap beef for fast foods such as hamburgers (14). Beef seekers in Western Europe are starting to promote similar "deforestation linkages" in Amazonia. They also stimulate deforestation in Thailand through marketplace demand for inexpensive food supplements in the form of cassava for feed-lot cattle; and they foster a spread of commercial ranching into savannah zones of Kenya, Botswana and other countries of Africa with an eye to the beef-export trade (15). These economic-ecologic linkages between the developed and the developing worlds seem likely to become more numerous, and more extensive in their impact as the global economy becomes increasingly integrated (16). Thus the problem of species extinction reflects not only growth in human numbers, but growth in human consumerism—an aspect of the situation that is occasionally accorded less than due attention by persons preoccupied with the basic issue of population explosion.

PROTECTED AREAS AND CLIMATIC CHANGE

The present network of protected areas has been established in accordance with present needs. The goal is to try to ensure that all biotic provinces, some 200 of them all together, are represented. Still, many biomes lack adequate representation in the network of protected areas. In fact, the total territory of protected areas needs to be increased about three times, or to about 100 million square kilometers, if it is to constitute a representative sample of the Earth's ecosystems (17). Of the tropical forests at least ten, and possibly 20 percent, should be protected according to some ecologists. Though the efforts at establishing protected areas to date are laudable, it must be recognized that many established areas are little more than "paper parks". Still, establishment of protected areas should remain a high priority while worthwhile areas are still available.

Even if sufficient areas are set aside for protection, climatic change may threaten their viability (18). As a result of the "greenhouse effect" due to increases in atmospheric CO_2, vegetation zones are predicted to shift outward from the equator. Such a shift would alter unique ecosystems within both forest and arid land parks. More local types of climatic disruption may also occur. Even if 10 percent of tropical forests are preserved, the destruction of the remaining 90 percent would result in decreased viability in the reserved areas. For example, a decline in rainfall due to deforestation in the unprotected 90 percent would gradually dry out the protected 10 percent, reducing its effectiveness as a refuge for the original forest species.

In short, the present global network of protected areas, even with additions, may prove incapable of meeting newly emerging needs even within the next few decades. Present day planners of parks and reserves should re-adapt their policies and programs to allow for the possible alterations of the next century.

THE ULTIMATE EXTINCTION OUTLOOK

Although projections of future extinction are speculative, they are helpful in gaining a better idea of the problems we confront. Professor Daniel Simberloff of Florida State University has looked at the case of Latin America, and he concludes that if deforestation continues at present rates (they are likely to accelerate) until the year 2000, but then were to halt completely, we should anticipate a loss of about 15 percent of all plant species. When one plant species disappears, it is likely to take with it between 10 and 30 associated animal species that depend upon it, in one way or another, for critical parts of their life cycles (19). Were Latin America's forests to be ultimately reduced to those areas set aside as parks and reserves, we should anticipate that 66 percent of plant species would eventually disappear, together with almost 69 percent of bird species. We may learn how to manipulate habitats to enhance survival prospects, we may learn how to propagate threatened species in captivity, and we may be able to apply other emergent conservation techniques, all of which will help the situation. In addition, and for reasons of "ecological

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equilibriation" (delayed fall-out effects), some extinctions may not occur until well into the 22nd century, or even further into the future. But the damage will have been done.

This writer hazards a best-judgement estimate that we may eventually lose a full quarter of all species that now share the Earth with us. This is an optimistic prognosis; it is possible that we will lose one-third, and conceivable that we will lose one-half of all species. Surviving species may lose a great part of their genetic variability. This would be a biological débâcle greater, in its compressed timescale, than any during the entire course of evolution.

That we will suffer severely in economic terms, through the loss of vast stocks of uniquely valuable natural resources is beyond dispute. What is far less certain is whether a mass extinction of species will not inflict serious ecological injury on that part of the planetary ecosystem that survives through the end of the next century. Some think a lack of genetic diversity in an ecosystem is associated with a loss of stability. What is not known is how much diversity loss the global ecosystem can endure before critical damage to our entire "life support system" occurs (20).

A FUTURE OUTBURST OF SPECIATION?

While we are plainly on the verge of an extinction episode, we are probably on the verge, also, of an outburst of speciation. As species disappear in large numbers, their passing will open up many ecological niches, allowing new subspecies and then species to emerge more rapidly than usual. An acceleration in the process of speciation, however, will not remotely match the compressed phenomenon of mass extinction. The time required to kill off a species is much shorter than that required to develop a new one. A compensatory increase in speciation will not occur within our time horizon of concern.

We should, however, prepare for a rapid increase in numbers of opportunistic species which capably exploit newly vacant niches. The adaptability of these species may allow them to become so successful that they will become pests. Present examples of such species include the house fly, the rat, and the rabbit, as well as many "weed" plants.

A trend favoring opportunistic species is not, in itself, harmful. Since these species are slow to settle into specialized niches they retain potential for future evolutionary adaptation. In this sense the genetic variability of opportunistic species may be considered greater than that of more established or "developed" species. The specialist species however, especially the parasites and predators, serve to limit the populations of opportunistic species—especially those most likely to become pests. To date, probably less than five percent of all insect species deserve to rank as pests, thanks to the attentions of their natural enemies. But if extinction patterns favor opportunistic species the result could be a situation in which harmful species increase until they exceed the capacity of natural enemies to control them.

DEGENERATIVE REPERCUSSIONS FOR EVOLUTION

The extinction of large numbers of species will not be the ultimate effect of the above scenarios. Rather, a potentially irreversible disruption of evolutionary processes that have steadily developed since the first flickerings of life could occur. The tropical forests, coral reefs and wetlands which are among the most threatened ecosystems are also the most sensitive and the most dynamic in terms of evolutionary processes.

Hence the impending extinction spasm could have far reaching consequences not only for Earth's array of species, but for the future course of evolution itself. As has been graphically stated: "Death is one thing; an end to birth is something else" (21). Yet we are allowing this basic disruption of evolution to proceed—with implications that could extend for millions of years into the future—with alarming complacency (22).

References and Notes

1. P R Ehrlich and A H Ehrlich, *Extinction: The Causes and Consequences of the Disappearance of Species* (Random House, New York, 1982); N Myers, *The Sinking Ark* (Pergamon Press, Oxford and New York, 1979), P R Raven, *Research Priorities in Tropical Botany* (National Research Council, Washington DC, 1980)
2. T L Erwin, "Tropical Forest Canopies, the Last Biotic Frontier", *Bulletin of the Entomological Society of America* 29, No 1, 14 (1983)
3. N Myers, *A Wealth of Wild Species* (Westview Press, Boulder, Colorado, 1983)
4. International Union for Conservation of Nature and Natural Resources, *World Conservation Strategy* (International Union for Conservation of Nature and Natural Resources, Gland, Switzerland, 1980)
5. Food and Agriculture Organization of the United Nations and United Nations Environment Program, *Tropical Forest Resources* (Food and Agriculture Organization, Rome, Italy, and United Nations Environment Program, Nairobi, Kenya, 1982), N Myers, *Conversion of Tropical Moist Forests* (National Research Council, Washington DC, 1980) and *The Primary Source, Tropical Forests and Our Future* (W W Norton, New York, 1984)
6. According to W Alvarez *et al*, "Extra-Terrestrial Cause of Cretaceous-Tertiary Extinction", *Science* 208, 1095 (1980) The seemingly sudden disappearance of the dinosaurs, together with many associated animal and plant species, was probably due to an asteroid colliding with the Earth, throwing up so much dust that sunlight was effectively blocked off, halting photosynthesis in many plant communities While there may be much truth to this hypothesis, let us recall that the dinosaurs had been declining for several million years before their final "instant dying"
7. The theme of the inter-relationships of conservation and development has been presented in many recent publications, eg International Union for Conservation of Nature and Natural Resources, *World Conservation Strategy* (International Union for Conservation of Nature and Natural Resources Gland, Switzerland, 1980); and The Brandt Commission, *North-South: A Programme for Survival* (Pan Books, London, 1980) For further analysis of resource relationships within an interdependent community of nations, set against a background of conservation and development linkages, see N Myers "The Exhausted Earth", *Foreign Policy* 42, 141 (1981)
8. N Myers, "Kenya's Baby Boom", *New Scientist* 87, 838 (1980)
9. P Harrison, "Land and Population The Growing Pressure" *People* 10 3 (1983), P Harrison and J Rowley, *Human Numbers Human Needs* (International Planned Parenthood Federation, London, 1984)
10. The World Bank, *World Development Report* (The World Bank, Washington DC, 1983)
11. O Mehmet, editor, *Poverty and Social Change in Southeast Asia* (University of Ottawa Press, Ottawa, Canada, 1979), International Labor Organization, *Poverty and Landlessness in Rural Asia* (International Labor Organization, Geneva, Switzerland, 1977); Food and Agriculture Organization of the United Nations, *Proceedings of World Conference on Agrarian Reform and Rural Development* (Food and Agriculture Organization, Rome, Italy, 1980).
12. J C Westoby, Keynote Address to the Institute of Foresters of Australia, Canberra 29th August, 1983.
13. L E Gilbert, *Food Web Organization and Conservation of Neotropical Diversity*, in M E Soule and B A Wilcox, editors, *op cit* 20, 34; and N Myers, *op cit* ref. no. 22
14. N Myers, "The Hamburger Connection: How Central America's Forests Become North America's Hamburgers," *Ambio* 10, 3 (1981).
15. N Myers, *op cit* 5; and N Myers, "The Cheetah in Africa," *International Union for Conservation of Nature and Natural Resources Monograph No. 4* (International Union for Conservation of Nature and Natural Resources, Gland, Switzerland, 1975)
16. N Myers and D M Myers, "From the 'Duck Pond' to the Global Commons: Increasing Awareness of the Supranational Nature of Emerging Environmental Issues," *Ambio* 11, 195 (1982), and N Myers and D M Myers, "How the Global Community Can Respond to International Environmental Problems," *Ambio* 12, 20 (1983)
17. *Proceedings of Third World Congress on National Parks* (International Union for Conservation of Nature and Natural Resources, Gland, Switzerland, 1984).
18. N Myers, "The Carbon Dioxide Connection, *Journal of Social and Biological Structures* 6 (1983). See also National Academy of Sciences *Changing Climate* (National Academy Press Washington DC, 1983), and Environmental Protection Agency, *Can We Delay a Greenhouse Warming?* (Office of Policy and Resources Management, Washington DC, 1983)
19. D Simberloff, "Are We on the Verge of a Mass Extinction in Tropical Rain Forests?" *Journal of Biogeography, in press*
20. M E Soule and B A Wilcox, editors, *Conservation Biology* (Sinauer Associates, Sunderland Massachussetts, 1980); and O H Frankel and M E Soule, *Conservation and Evolution* (Cambridge University Press, London and New York, 1982)
21. M E Soule and B A Wilcox, *Ibid*.
22. N Myers, "A Fundamental Shift in Evolution Ahead of Us?," *The Sciences* (New York, 1984, in press)

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