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TO: All Members of the World Commission on Environment and Development

FROM: Jim MacNeill
Secretary General

DATE: 1 December, 1986

RE: Disappearing Species: A Major Resource and Development Challenge

You will recall that in Harare it was decided to add a new Chapter on conservation of natural resources with a special focus on the destruction of tropical forests and disappearing species. Subsequently, following consultation, I engaged the noted expert and consultant Dr Norman Myers to prepare the enclosed draft for our consideration. A preliminary draft has been reviewed by a number of peers, a process that is continuing with this and other Chapters.

Dr Myers will be in Moscow to participate in the discussion, following which the Chapter will be revised for further, and hopefully final, consideration in January.

The present draft has not been edited by Linda Starke, and a selection of quotations from the Public Hearings has not been made yet, and is therefore not reflected in the present text.

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CHAPTER 9

DISAPPEARING SPECIES: A MAJOR RESOURCE AND DEVELOPMENT CHALLENGE

December 1986

"The worst thing that can happen during the 1980s is not energy depletion, economic collapse, limited nuclear war, or conquest by a totalitarian government. As terrible as these catastrophes would be for us, they can 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 that our descendants are least likely to forgive us."

Professor Edward O. Wilson, Harvard University

CHAPTER 9

DISAPPEARING SPECIES: A MAJOR RESOURCE AND DEVELOPMENT CHALLENGE

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CHAPTER 9

DISAPPEARING SPECIES: A MAJOR RESOURCE AND DEVELOPMENT CHALLENGE

I. INTRODUCTION

1. There is strong evidence that we are witnessing the start of a mass extinction of species. Our global environment is being subjected to many forms of degradation. But only one form is essentially irreversible, and that is species extinction. If we decide to do so, we can clean up pollution, we can push back the desert fringe, and we can turn around virtually all other types of environmental depletion. True, we shall generally find it expensive, and it will take us a good time. But it is inherently feasible. By contrast, extinction falls into a category of its own. When a species is gone, it is gone for good - and all too often, we shall find that is for bad, if only in terms of our material welfare.

2. This Chapter reviews the scope and scale of the extinction spasm that is overtaking Earth's biotas. It examines the causes and mechanisms involved. It considers the costs it imposes on us, as on all future generations. At the same time, it emphasizes that there is little inevitable about the phenomenon: that if we choose to do so, we can slow and even halt the process of mega-extinction. There is no doubt that we still have time, though only just time, to get to grips with the

problem. While the extinction episode ahead of us threatens to be the greatest setback to life's abundance and diversity since the first emergence of life four billions years ago, it also presents us with a remarkable challenge: to save threatened species in their millions.

3. Thus the extinction crisis is not only a major problem. It is an unprecedented opportunity.

II. THE PROBLEM: CHARACTER AND EXTENT

4. There is much evidence of an extinction spasms impending. In Madagascar, there are, or rather there were until recently, 9500 documented plant species and probably around 190,000 animal species, with at least 60 per cent of them endemic to the island's eastern strip of forest (that is, found nowhere else on Earth). At least 93 per cent of the original primary forest has been eliminated.[1/] According to best scientific analysis, this means that at least half of the original species have already disappeared, or are on the point of doing so - a full 60,000 of them.

5. In the Caribbean, with its 50,000 coral-reef species, whole communities are at risk through marine pollution. One sixth of the world's oil is produced in or shipped through the Caribbean, and supertankers, plus offshore oil rigs, inject more than 100 million barrels of oil into the sea each year.[2/]

6. In the Cape Floristic Kingdom of South Africa, there are 6000-plus plant species, 70 per cent of them endemic, in only 18,000 square kilometres (the 1.5 million square kilometres of the northeastern United States feature only 550 plant species, and only a few

hundred endemics). Yet the area suffers acute problems of encroaching agriculture, over-frequent fires and invasive exotic plants, threatening at least 2000 plant species (or almost as many as in the entire United States).[3/]

7. In the Pantanal area of Brazil, there are 110,000 square kilometres of wetlands, probably the most extensive and richest wetlands in the world. They support the largest and most diversified populations of waterfowl in South America; and they surely harbour a large number of endemic invertebrates. The area has been classified by UNESCO's World Heritage system as "of international importance". Yet it suffers increasing encroachment from agriculture, hydropower projects, and other forms of disruptive development.[4/]

8. In Central Africa, the 29,000 square kilometre Lake Malawi features 500-plus cichlid species, 99 per cent of them endemic. The lake is only one eighth the size of North America's Great Lakes, which feature only 173 species, fewer than 10 per cent of them endemic. When we count in the other lakes of Africa's Rift Valley, we find there are more than 930 endemic cychlids (plus more than 100 other endemic species). Yet Lake Malawi is threatened through pollution from industrial installations and proposed introduction of alien species.[5/] In Lake Victoria, with only some 300 endemic cichlid species, introduced predators, among other problems are likely to reduce the flock of endemics by 80-90 per cent within another decade at most. This is all the more regrettable in that the cichlid family of fishes, including the multiple species of tilapia, offers first-rate genetic diversity in support of aquaculture (which ranks among the most promising sources of animal protein).

9. There are many such ecosystems: exceptionally rich biologically, exceptionally promising in their potential material benefits, and exceptionally threatened (see Figures 9-1 and 9-2 and Table 9-1, for some details of habitat loss and threatened species). It is ironic, moreover, that we are allowing these vast stocks of biotic diversity to disappear (and to disappear in the twinkling of an evolutionary eye) precisely at the time when we are learning how to exploit genetic variability through the quantum advances of genetic engineering.

10. All in all, there are many portents of a major extinction episode underway.[6/ 7/ 8/ 9/ 10/ 11/ 12/ 13/] with examples from all major biomes, notably tropical forests, coral reefs, mangroves, savannahs and grasslands, temperate forests, arid zones, and so forth. True, most of these portents are generalized in their documentation; they do not offer lengthy lists of individual species at risk or recently extinct. But there are also particular cases with species-by-species details, such as the 90 endemic plants and their associated animal species, discovered only a few years ago on a 20 square kilometre ridge of western Ecuador and entirely eliminated today through logging and settlement agriculture.[14/]

11. Nor is the extinction of species the entire situation. There is extreme biotic impoverishment underway within species as well as among them. Each species represents the outcome of evolutionary processes that have generated a discrete amalgam of genetic variability. Although intraspecies genetic differences may sometimes appear slight, they are often quite pronounced. An immediate 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 breeders.[15/] [16/]

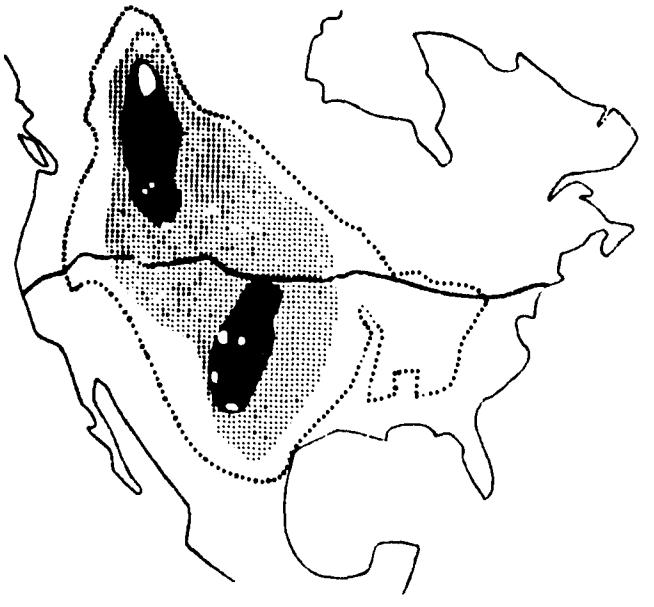
12. This means there is another dimension to the impoverishment that is overtaking Earth's biotas. Many species are losing whole sub-units, in the form of races and populations, at a rate that greatly reduces their genetic variability. Even though these species are not being endangered in terms of their overall numbers, they are suffering a critical decline in their genetic makeup.

13. 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 harboured only a few decades ago, even though the species themselves are anything but threatened. (The issue of genetic variability is too technical for us to go further into it here. The interested reader may wish to consult Appendix 1).

14. Overall, then, there are abundant signs that we are witnessing the onset of a mass extinction event. In the course of this Chapter, we shall look at the nature and extent of the phenomenon. We shall examine some of its mechanisms and dynamics. We shall go on to ask how far it can be countered by enhanced management of wildland environments and their biotas, and - most important of all - in what ways the problem relates to the context of development processes overall.

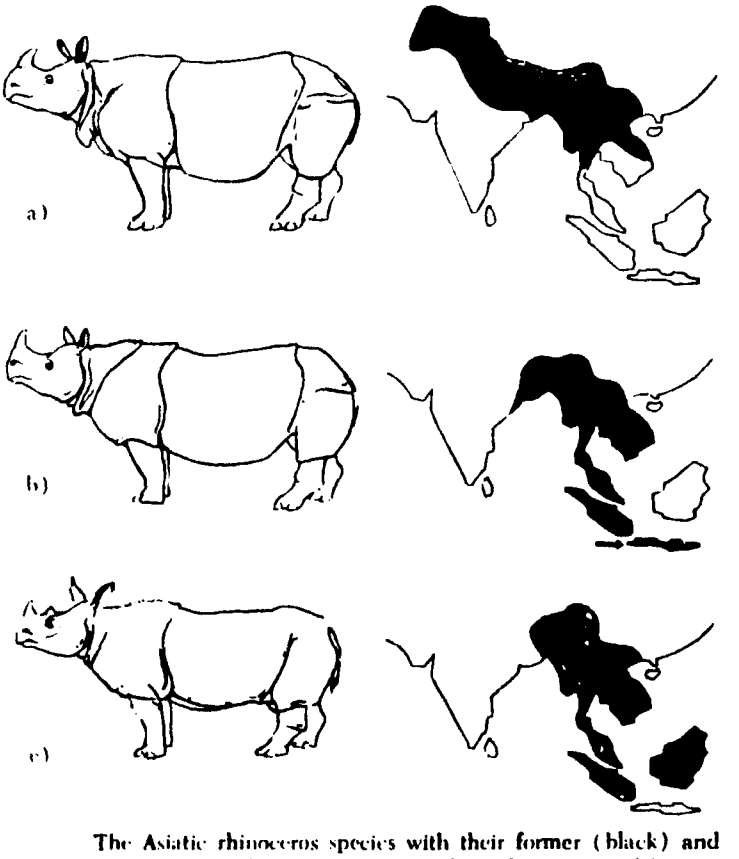
Figure 9-1

SPECIES THREATENED THROUGH HABITAT LOSS



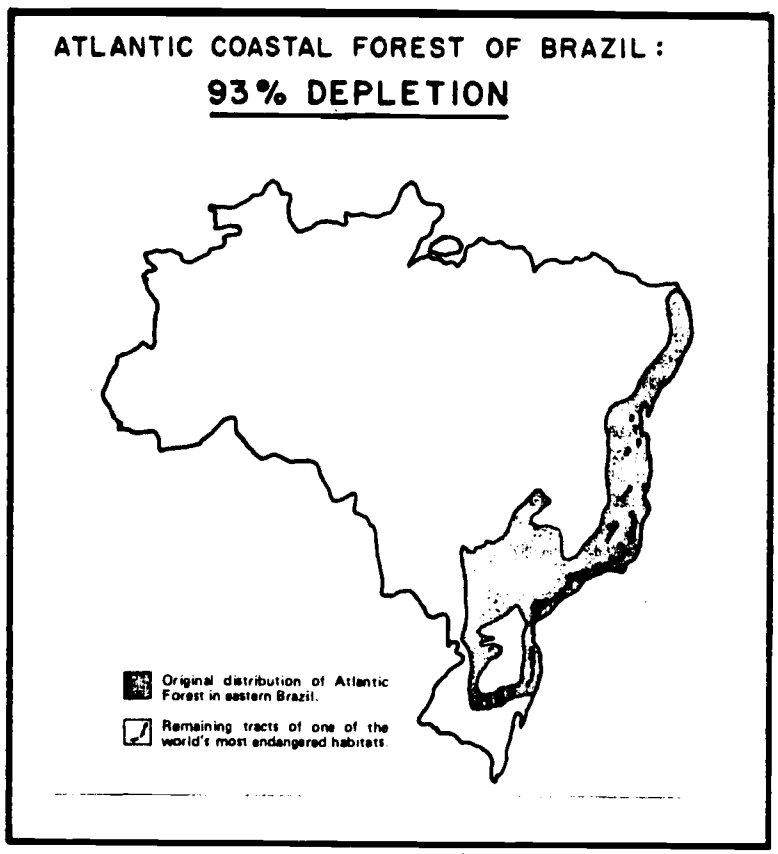
The former and current distribution of the North American buffalo. The dotted line encloses the range before 1800. The stippled area represents the range about 1850, the black areas represent the range about 1875; and the white areas, the current occurrence. The Union Pacific Railway is indicated by the solid line.

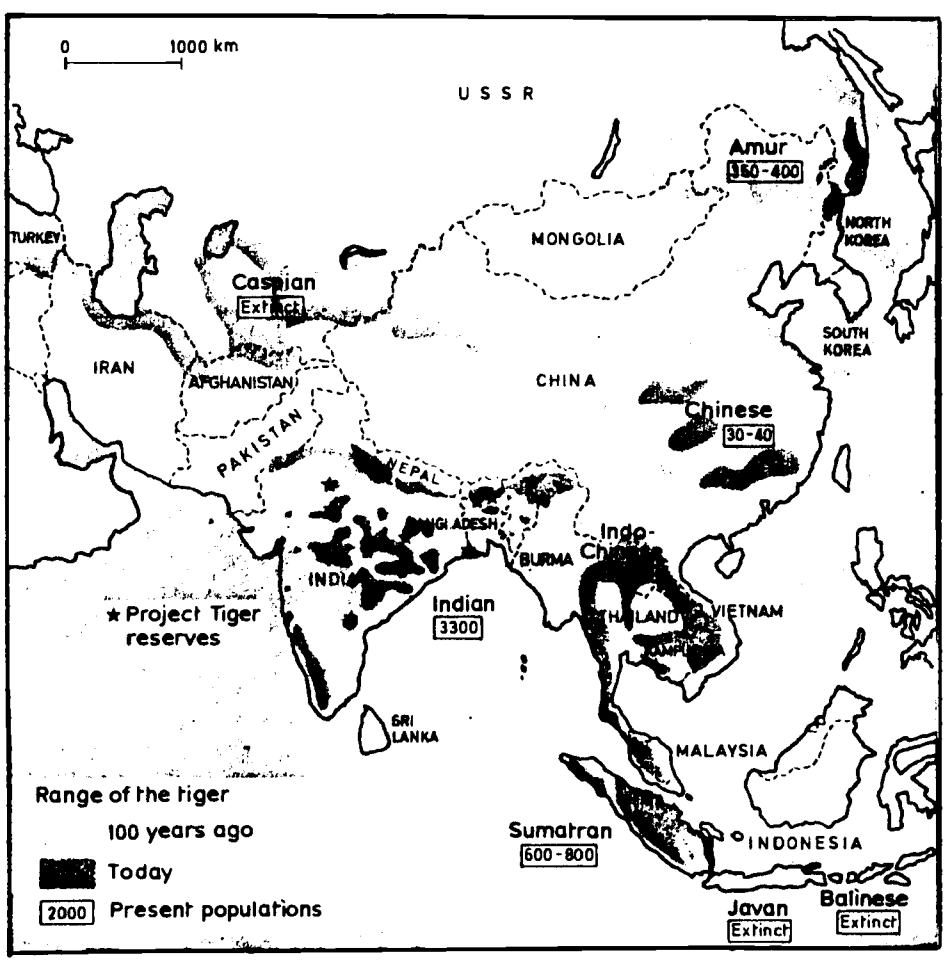
Former (stippled) and present (black spot) distribution of the Indian lion.



The Asiatic rhinoceros species with their former (black) and present (white spots) distribution. (a) Indian rhinoceros; (b) Java rhinoceros; (c) Sumatra rhinoceros.

Figure 9-2





Source: Ziswiler, 1967

Table 9-1

PLANT SPECIES: AREAS, SPECIES CONCENTRATIONS, ENDEMICS, THREATS

Area	Species Total	Endemics, %	Nos. Threatened
Continental United States, 9.36 million sq. kms.	16,500		2140 (74 already extinct)
California Floristic Province, 324,000 sq. kms.	5,050	30	1136
Minnesota, 198,222 sq. kms.	1,700	0.06	
Hawaii, 16,641 sq. kms.	950 or so	(great majority)	40% or so (about 100)
Europe (outside Soviet Union), 5.68 million sq. kms.	11,300		1927 (27)
British Isles, 308,000 sq. kms.	1,822	0.8	
Australia, 7.68 million sq. kms.	25,000-plus	50 occupy ranges of less than 100 sq. kms.	2038 (117)
New Zealand, 268,704 sq. kms.	1,996	81	190 (42)
Costa Rica, 50,899 sq. kms.	8-10,000	15 or so	
La Selva Reserve, 730 has.	1,500		
Panama, 78,513 sq. kms.	8,500	14	
Barro Colorado Island, 15.6 sq.kms.	1,369		
Colombia, 1.14 million sq. kms.	45,000 or so		
Choco Dept., 47,200 sq. kms.	10,000 or so	25 or so	
Venezuela, 912,047 sq. kms.	15-25,000	30-plus	
Avila Flora Area, 175 sq. kms.	1,892		
Guyana Highlands, c. 500,000 sq. kms.	8,000 or so	75 or so	
Ecuador, 461,777 sq. kms.	20,000 or so	20 or so	
Rio Palenque Biological Station, 1.7 sq. kms.	1,250	4	
India, 3.17 million sq. kms.	15,000 or so	33 or so	
Himalayan Zone, 400,000 sq. kms.	10,000 or so	45 or so	
Sri Lanka, 65,610 sq. kms.	2,900 or so	30 or so	
Peninsular Malaysia, 131,587 sq. kms.	8,500 or so	(quite low)	
Sumatra, 457,150 sq. kms.	9,000 or so	12	
Borneo, 700,267 sq. kms.	10,000 or so	34	
New Guinea, 763,942 sq. kms.	9,000 or so	90	
Philippines, 299,498 sq. kms.	8,000 or so	44 or so	
New Caledonia, 16,750 sq. kms.	3,250	76	
Southern Africa (Namibia, Botswana, South Africa, Lesotho, Swaziland and the "homeland states"), 2.67 million sq. kms.	23,200	80	2375 (39)
Cape Floristic Kingdom, 18,000 sq. kms.	8,579	68	2000 (38)
Madagascar, 566,642 sq. kms.	9,500 minimum	60-80	

III. EXTINCTION PATTERNS AND TRENDS

1. Extinction Rates: Past and Present

15. Let us now address the key question of how fast species are being eliminated. Extinction has been a fact of life virtually since life's first emergence. Of an estimated half billion species that have ever existed, the present few millions are the modern-day survivors. Almost all past extinctions, however, have occurred by virtue of natural processes. Today, by far the predominant influence in the situation is man, who eliminates whole habitats, complete communities of species, in super-short order.

16. If we reckon that the average duration of a species is, roughly speaking, some five million years, and if we further reckon that there has been a crude average of 900,000 extinctions every one million years during the last 200 million years, then the average "background rate" of extinction has been, a very rough-and-ready estimate, one in every one and one-ninth years.[17/] The present human-caused rate is certainly hundreds of times higher, and could easily be thousands of times higher.[18/]

17. We have no concise grasp of the rate of extinctions right now. The great majority of species in question are precisely those, such as insects and other arthorpods in tropical forests, that are least documented. We know all too little about their very existence, let alone about their survival status. So we are far from having an exact picture of what is happening.

18. To help us gain an insight into the situation, we shall take a lengthy look at tropical forests. Indeed much of our analysis will focus on this one biome, since it is by far the richest in biotic senses and by far the most threatened through man's activities. But this is not to gainsay the claims of other major ecological zones. Coral reefs, for instance, with an estimated half million species in their 400,000 square kilometres, are likewise undergoing progressive depletion (from suffocating under increased silt loads from dynamiting for cement, etc.) at a rate that may leave little by early next century except in the form of degraded remnants. This is all the more regrettable in that coral-reef organisms, by virtue of the "biological warfare" they engage in to ensure living space in crowded habitats, have generated an unusual number and variety of toxins, that prove uniquely valuable in modern medicine. 19/ Suffering most attrition of all is probably the wetlands biome: on every side, marshes and swamps are being drained to make way for human settlements and other more "valuable" types of land use. 20/ But because tropical forests are a super-special case, we shall direct most attention at them.

2. The Special Case of Tropical Forests

19. There is general agreement that tropical forests, while covering only 6 per cent of Earth's land surface, contain at least 50 per cent of Earth's 5 million species. If we accept some higher estimates, Erwin, 21/ postulates between 30 and 50 million) for the total of tropical forest species, then the biome could conceivably contain 90 per cent or even more of Earth's species. There is also general agreement that remaining primary forests cover only 9 million square kilometres, out of 16 million square kilometres that once existed; that between 76,000 and 100,000 square kilometres are eliminated

outright each year; and that at least a further 100,000 square kilometres are grossly disrupted each year. Note that these figures derive from a data base of the late 1970s.[22/ 23/ 24/ 25/ 26/ 27/] Since the data were assembled, the deforestation rates have increased somewhat.

20. This means, roughly speaking, that one per cent of the biome is being deforested each year, and rather more than another one per cent is being significantly degraded. By the end of the century or shortly thereafter, there could be little left of the biome in primary status, with full complement of species, outside of two large remnant blocs, one in the Zaire Basin and the other in the western half of Brazilian Amazonia, plus some outlier areas such as the Guyana tract of forest in norther South America and perhaps parts of the island of New Guinea. Moreover, these relic sectors of the biome are little likely to survive beyond a few further decades, if only because of sheer expansion of impoverished throngs of forestland farmers.

21. As a measure of what rapid population growth (through immigration rather than natural increase) can impose on tropical forests, viz. through the phenomenon of the shifted cultivator, consider the situation in Rondonia, a state in the southern sector of Brazilian Amazonia. Since 1975, the population has grown from 111,000 to more than 1.2 million today, i.e. more than a ten times increase in less than a dozen years. In 1975, around 1250 square kilometres of forest were cleared. By 1982, this amount had grown to more than 10,000 square miles (should be in km?), and by early 1985 to almost 16,000.[28/ 29/ 30/]

22. To help us gain more precise insight into the scope and scale of present extinctions, let us look briefly at three particular areas, viz. the forested tracts of western Ecuador, Atlantic-coast Brazil and Madagascar. Each of these areas features, or rather featured, exceptional concentrations of species, with high levels of endemism. Western Ecuador is reputed to have once contained between 8000 and 10,000 plant species, with an endemism rate somewhere between 40 and 60 per cent.[31/] If we suppose, as we reasonably can by drawing on detailed inventories in sample plots, that there are between 10 and 30 animal species for every one plant species, the species complement in western Ecuador must have amounted to about 200,000 in all. Since 1960, almost the entire forest cover of western Ecuador has been destroyed, to make way for banana plantations, oil exploiters and human settlements of various sorts. How many species have thus been eliminated, or are on the verge of being eliminated, is difficult to judge. But they could well number around 50,000 - all accounted for in just 25 years.

23. Similar baseline figures, and a similar story of forest depletion, though for different reasons and over a longer time period, apply to the Atlantic-coastal forests of Brazil.[32/] and to Madagascar [33/] So in these three areas alone, with their 600,000 species, half of them endemics, the recent past must have witnessed a sizeable fallout of species. True, in Brazil and Madagascar the forest clearing has been going on for several centuries rather than a few decades. But the worst damage has been done since 1950, due to ultra-rapid spread of human settlements in both, together with expansion of industry in the first and small-scale cultivation in the second. So it is not unrealistic to

surmise that in these three areas alone, the extinction rate could well have reached a crude average of several species a day since about 1950, with a higher rate in more recent years as growth of both population and economic activity has made itself felt.

3. Extinction Rates: Future

24. As for the future, the outlook seems all the more adverse, though its detailed dimensions are still less clear than those of the present. Despite the uncertainty, however, it is worthwhile to delineate the nature and compass of what lies ahead, in order to grasp the scope of the extinction spasms that impends.

25. Let us look again at tropical forests. We have already seen what is happening to three critical areas. We can identify a good number of other sectors of the biome that are similarly ultra-rich in species, and that likewise face severe threat of destruction. They include the Mosquitia Forest of Central America; the Choco forest of Colombia; the Napo centre of diversity in Peruvian Amazonia, plus six other centres (out of 20-odd centres of diversity in Amazonia) that lie around the fringes of the basin and hence are unusually threatened by settlement programmes and various other forms of development; the Tai Forest of Ivory Coast; the montane forests of East Africa; the relic wet forest of Sri Lanka; the monsoon forests of the Himalayan foothills; Sumatra; northwestern Borneo; certain lowland areas of the Philippines; and several islands of the South Pacific (New Caledonia, for instance, with 18,500 square kilometres, or only half the size of Switzerland, contains 3000 plant species, 80 per cent of them endemic).

26. These 20 sectors of the tropical forest biome amount to roughly one million square kilometres, or only one tenth of remaining undisturbed forests. So far as we can best judge from documented numbers of plant species, [34/] and by making substantiated assumptions about the numbers of associated animal species, we can reckon that these 20 areas surely harbour one million species (assuming a low planetary total of 5 million species). If present land-use patterns and exploitation trends persist, there will be little left of these forest tracts, except in the form of degraded remnants, by the end of this century or shortly thereafter. Thus deforestation in these areas alone could well eliminate very large numbers of species, surely hundreds of thousands, within the next 20 years at most.

27. Looking at the situation another way, we can reckon, on the basis of what we know about plant numbers and distribution, together with what we can surmise about their associated animal communities, that almost 20 per cent of all species on Earth occur in forests of Latin America outside of Amazonia; and another 20 per cent in forests of Asia and Africa outside the Zaire Basin.[35/] All of the forests in which these species occur may well disappear by the end of this century, or early in the next at the latest. If only half of the species in these forests disappear, this will amount to at least three-quarters of a million species.

28. How about the prognosis for the longer term future, to the effect that eventually we could lose at least one quarter, possibly one third, and conceivably a still larger share of all existent species? Let us take a quick look at the case of Amazonia.[36/] If deforestation continues at present rates (it is likely to accelerate) until the year 2000, but then were to halt completely (a big supposition indeed), we should

anticipate a loss of about 15 per cent of plant species. The Calculation behind this loss figure is entirely reasonable and documentable, based as it is on the well-established theory of island biogeography.[37/] and abundant evidence of pervasive deforestation patterns in Amazonia. Were Amazonia's forest cover to be ultimately reduced to those areas now set aside as parks and reserves, we should anticipate that 66 per cent of plant species would eventually disappear, together with almost 69 per cent of bird species, and similar proportions of all other major categories of species.

29. Of course, we may learn how to manipulate habitats to enhance survival prospects. We may learn how to propagate threatened species in captivity. We may be able to apply other emergent conservation techniques, all of which could help to relieve the adverse repercussions of broad-scale deforestation. But in the main, the damage will have been done. For reasons of island biography, and of "ecological equilibration" (delayed fall-out effects), some extinctions in Amazonia will not occur until well into the 22nd century, or even further into the future. So a major extinction spasm in Amazonia is entirely possible, indeed plausible if not probable.

4. Tropical Forests and Climatic Change

30. Nor are protected areas likely to provide a sufficient answer, for reasons that go beyond island biogeography and incorporate a climatic dimension. In Amazonia, for instance, it is becoming apparent that if as much as one half of the forest were to be safeguarded in some way or another (through e.g. multiple-use conservation units as well as protected areas), but the other half of the forest were to be eliminated or severely disrupted, there could soon be at work a hydrological feedback mechanism that would allow a good

part of Amazonia's moisture to be lost to the ecosystem.[38/] The outcome for the remaining forest would be a steady desiccatory process, until the forest became more like a woodland - with all that would mean for the species communities that are adapted to forest habitats. Even with a set of forest safeguards of exemplary type and scope, Amazonia's biotas would be more threatened than ever.

31. Still more widespread climatic changes, with yet more marked impact, are likely to emerge within the foreseeable future. By the first quarter of the next century, we may well be experiencing the climatic dislocations of a planetary warming, stemming from build-up of carbon dioxide and other "greenhouse gases" in the global atmosphere.[39/] [40/] The consequences for protected areas will be pervasive and profound. The present network of protected areas has been established in accordance with present-day needs. The current goal is to ensure that all biotic provinces, several hundred altogether, are represented. Many biomes still lack adequate representation. Indeed a consensus of professional opinion suggests that the total expanse of protected areas needs to be increased at least three times, or to about 12.5 million square kilometres, if it is to constitute a representative sample of Earth's ecosystems.[41/] Of tropical forests, at least 20 per cent should be protected, but to date well under 5 per cent has been afforded protection of any sort - and of such parks as exist, a good number are "paper parks."

32. But even if sufficient areas were to be set aside for protection of all wildlife communities and threatened species, their viability will soon be threatened as vegetation zones, in the wake of broad-scale climatic change, start to "migrate" away from the Equator - with all manner of disruptive repercussions for natural

environments. In short, the present global network of protected areas, even with additions, may prove incapable of meeting newly emergent needs that appear set to appear during the next few decades. Present-day planners of parks and reserves should urgently seek to adapt their policies and programmes accordingly.[42/] Regrettably, only one conservation body is addressing the issue in substantive fashion.

33. These, then, are some dimensions of the extinction spasm that we can reasonably assume will overtake the planet's biotas within the next few decades (unless of course we do a massively better job of conservation; see below). We have gone into the evidence in some detail, in order to document the case for an impending extinction spasm that could eliminate as many as half of all species on Earth, and thus precipitate a biotic and evolutionary crisis as great as any since the first emergence of life almost four billion years ago. Not all conservationists and scientists realize the full scope and scale of the phenomenon that is overtaking the planet's biotas. Let us note, moreover, that the crisis is not primarily concerned with charismatic creatures like the panda, the tiger or the California condor. It is concerned almost entirely with plants and insects - species that are hundreds of times more numerous than mammals and birds, that are ecologically much more important, and that offer far more potential for material benefit to humankind.

34. In effect we are conducting an irreversible experiment of global scale with the myriad array of species that we are fortunate to share the planet with - and we appear to be conducting our experiment with scarcely a thought for what we are doing.

IV. ECONOMIC VALUES AT STAKE

35. We might be better inclined to give more thought to the issue if we were to consider some economic values at stake.[43/] [44/] For sure, there are all manner of other reasons why we should be concerned - more pertinent in principle, less productive in practice. Among these many other reasons, there are the biological, ecological and genetic attributes of species, together with their aesthetic, cultural and ethical values,[45/] [46/] [47/] that could count as much in the long run as those attributes that may well help the threatened-species cause in the immediate future[48/]

36. But the economic values inherent in species, especially in their genetic materials, provide an "instant rationale" that should help carry the day during the next few decades - particularly in the tropics, which, with at least two-thirds of all species and a still greater proportion of threatened species - is roughly co-extensive with the Third World. However much developing nations may recognize the need in principle to safeguard threatened species, they usually lack the conservation resources (that is, the scientific skills, institutional capacities and funds) to do the job. To the extent that species can be enabled to "pay their way in the marketplace", their prospects for survival are enhanced.

37. From the morning cup of coffee to the evening nightcap of drinking chocolate, we benefit at multiple points in our daily lifestyles from species and their genetic resources. Without knowing it, we utilize hundreds of products each day that owe their origin to wild plants and animals. Our daily bread, for instance.

Corn and wheat have been made bountiful largely through the efforts of crop breeders rather than through huge amounts of fertilizers and pesticides - and crop breeders are increasingly dependent on genetic materials from wild relatives of corn and wheat. In common with all agricultural crops, the productivity of modern corn and wheat is sustained through constant infusions of germplasm. Thanks to this regular "topping up" of the genetic constitution of the United States' main crops, the U.S. Department of Agriculture estimates that germplasm contributions lead to increases in productivity that average around one per cent annually, with a farm-gate value of well over $1 billion (1980 values).[49/] To this extent, then, we enjoy our daily bread by partial grace of the genetic variability that we find in wild relatives of modern crop plants.

38. And "we" means each and every one of us. Whether we realize it or not, we enjoy the exceptional productivity of modern corn, and the exceptionally cheap price at which its products are available, thanks in large measure to its genetic constitution. Since cornstarch is used in the manufacture of sizing for paper, we benefit from corn each time we read a magazine. The reader of this Chapter is enjoying corn by virtue of the "finish" of the page he or she is looking at right now. The same cornstarch contributes to our lifestyles each time we put on a shirt or blouse. Cornstarch likewise contributes to the glue, so we benefit from corn each time we mail a letter. And the same applies, through different applications of corn products, whenever we wash our face, apply cosmetics, take aspirin or penicillin, chew gum, eat ice cream (or jams, jellies, catsup, pie fillings, salad dressings, marshmallows, or chocolates), and whenever we take a photograph, draw with crayons, or utilize explosives.

Corn products also turn up in the manufacture of tyres, in the moulding of plastics, in drilling for oil, in the electroplating of iron, and in the preservation of human blood plasma.

39. Let us recall moreover that the U.S. corn crop suffered a severe setback in 1970, when a leaf fungus blighted croplands throughout its main range, causing losses to farmers, hence to consumers too, worth more than $2 billion. The situation was saved when fungus-resistant germplasm was found in genetic stocks that originally came from Mexico. More recently a further variation of corn germplasm has been discovered in a montane forest of south-central Mexico. 50/ The wild plant is the most primitive known relative of modern corn; and at the time of its discovery, it was surviving in only three tiny patches, covering a mere four hectares - a habitat that was threatened with imminent destruction by squatter cultivators and commercial loggers. The wild species turns out to be a perennial, unlike all other forms of corn which are annuals. Now that it has been cross-bred with established commercial varieties of corn, it opens up the prospect that corn growers (and corn consumers) could be spared the seasonal expense of ploughing and sowing, since the plant would spring up again of its own accord, like grass or daffodils.

40. Even more important, the wild corn offers resistance to at least four of eight major viruses and mycoplasmas that have hitherto baffled corn breeders.51/ These four diseases cause at least a one per cent loss to the world's corn harvest each year, worth more than $500 million. Equally to the point, the wild corn, discovered at elevations between 2500 and 3300 metres, is adapted to habitats that are cooler and damper than established cornlands. This offers scope to expand the cultivation range of corn by a much as one tenth.

All in all, the genetic benefits supplied by this wild plant, surviving in the form of no more than a few thousand last stalks, could total several billion dollars per year. 52/

41. Wild species likewise contribute to our health needs. Each time we take a prescription from our doctor to the neighbourhood pharmacy, there is one chance in two that our purchase - whether an antibiotic, tranquillizer, diuretic, laxative, or contraceptive pill, owes its origin to startpoint materials from wild organisms. 53/ The commercial value of these medicines and drugs in the United States now amounts to some $14 billion a year. 54/ If we extend the arithmetic to all nations, and include non-prescription materials plus pharmaceuticals, the commercial value tops $40 billion a year.

42. As a specific example of plant source of drugs, let us note the rosy periwinkle, a plant originally from Madagascar's forests. The periwinkle harbours alkaloids that yield two potent therapies against Hodgkin's disease, leukemia and other blood cancers. Commercial sales of the two drugs now total more than $150 million per year. When we assess the economic benefits too, viz. workers' productivity time saved and the like, we find the value to American society alone can be estimated at more than $300 million per year. According to the National Cancer Institute, 55/, 56/ there could well be another five plants in Amazonia alone, with capacity to generate superstar drugs against cancer. This clarifies for us the data presented above on projected plant extinctions in Amazonia - and let us recall that Madagascar's forests, the periwinkle's native habitat, are now 93 per cent destroyed, with half their species presumed lost or about to be lost.

43. We also derive many industrial benefits from wildlife.[57/] [58/] As technology advances in a world growing short of many things except shortages, industry's needs for new raw materials expands with every passing day. Wildlife-derived materials contribute by way of gums and exudates, essential oils and ethereal oils, resins and oleoresins, dyes, tannins, vegetable fats and waxes, insecticides, and multitudes of other biodynamic compounds. Many wild plants bear oil-rich seeds with potential for the manufacture of fibres, detergents, starch, and general edibles. For instance, the Fevillea genus of rainforest vines in western Amazonia bear fruit seeds with a higher oil content than is the case with any other dioctyledonous plant; if naturally occurring lianas in a patch of rainforest were to be cut and replaced by Fevillea vines, the per hectare oil yield would prove comparable to those obtained in the most productive oilpalm plantations - and could be obtained without felling a single tree.[59/]

44. Still more important, a few plant species contain hydrocarbons rather than carbohydrates - and hydrocarbons are what make petroleum petroleum.[60/] [61/] A number of wild plant species appear to be candidates for "petroleum plantations." As luck would have it, certain of these plants can flourish in areas that have been rendered useless through, for example, strip-mining. Hence we have the prospect that land that has been degraded by extraction of hydrocarbons from beneath the surface could be rehabilitated by growing hydrocarbons above the surface. Moreover, a petroleum plantation need never run dry like an oil well.

45. We enjoy these myriad products after scientists have undertaken only a superficial examination of the genetic resources available to us from wild species. In fact, scientists have taken a look at only 10 per cent of

all plant species, and they have taken a close look at only one per cent. Well might we assert, then, that Earth's stock of species, with the genetic materials they harbour, represent some of the most valuable raw materials with which we can confront the unknown challenges of the future.

46. Fortunately, we can look forward to expanding our use of wild genetic resources, thanks to the burgeoning industry of bioengineering and its associated technologies. Genes are the hereditary materials of each species' makeup; we can isolate and manipulate them. So the emergent field of bioengineering places a premium on a broad array of genetic variability. This throws new light on the phenomenon of extinction, which, to cite Professor Tom Eisner of Cornell University,[62/] "no longer means the simple loss of one volume from the library of nature. It means the loss of a loose-leaf book whose individual pages, where the species to survive, would remain available in perpetuity for selective transfer and improvement of other species." We can also note a parallel comment from gene-splicing expert Professor William Brill of the University of Wisconsin [63/]: "We are entering an age in which genetic wealth, especially in tropical areas such as rainforests, until now a relatively inaccessible trust fund, is becoming a currency with high immediate value."

47. Thanks to bio-engineering, it is becoming plain that in the field of agriculture the Green Revolution is being superseded by a still more revolutionary phenomenon, the Gene Revolution. This is a breakthrough in agricultural technology that may soon enable us to harvest crops from deserts, farm tomatoes in seawater, grow super-potatoes in many localities that have hitherto remained off limits, and enjoy entirely new crops such as a "pomato". A similar prospect applies with respect to medicine,

where we can look forward to one advance after another to match the discovery of penicillin. Medical pioneers foresee more innovative advances during the last two decades of this century than during the previous two centuries. As for industry, our creative applications of the gene reservoirs of wild species may soon make our present industrial science appear like a hangover from the Stone Age. In short, we may steadily find ourselves becoming more prosperous in our daily welfare, more sophisticated in our technological know-how, and more sensitive in our use of Earth's renewable resource, by virtue of a new "discover nature" movement.

48. On a more negative side, let us note that the values cited with respect to medicinal plants allow us to calculate - albeit in rough and ready terms, and for illustrative purposes only - the commercial cost of allowing a species to become extinct. (Let us bear in mind too, as demonstrated by the case of the Madagascar periwinkle, that the economic cost is likely to be much greater.) Scientists have so far conducted semi-detailed examination of only about 5000 of the 250,000 species of higher plants. Of these 5000 analysed, 41 have produced materials that serve our health needs in one way or another;[64/] and the 41 species now generate commercial sales worldwide each year worth about $40 billion, or an average of almost $1 billion each. Of course, the genetic materials contribute only limited part of the eventual commercial value. But the pharmacologist is no better than the raw materials he has to work with, so even if the genetic contribution represents a small part of the end-product, it is an essential part.

49. Let us suppose the 245,000 species still to be subjected to systematic analysis were to come with "winners" at a rate of one for every 122. Let us also accept that at least one plant species in ten is now threatened, and could well be eliminated by the year 2000

(one plant species in four could disappear in tropical forests alone by the year 2050, according to Raven.[65/] If these 25,000 threatened species were to offer medicinal potential at a rate of one in every 122 species, then we should lose 205 species with materials for drugs. Of course, some of the drugs may serve the same purpose, so there could be some overlap between the benefits supplied by the species in question; and some of the drugs could prove to be amenable to synthesis in the laboratory. But in terms of the "back of an envelope" calculations presented here, this spasm of plant extinctions could cost us $205 billion each year in medicinal terms alone. This figure is to be compared with a crude-estimate cost of expanding our present network of protected areas until it caters for the present needs of the majority (though not the totality) of all species on Earth, both plants and animals, viz. some $1 billion a year for ten years.

V. SOME CAUSES OF EXTINCTION

Let us now move on to examine some of the main causes of extinction.

1. Population Growth[66/]

50. The tropics, which host the greatest number and diversity of species, also lie mainly within the developing world, where population growth is greatest. But let us recognize that population growth need not be 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, are little likely to achieve a parallel degree

of urbanization, even by the end of the next century. There will surely be huge numbers of people still living in rural areas and pursuing agricultural lifestyles.

51. Indeed, by the end of the next century there are projected to be three-fifths more people living in rural areas in the Third World than there are today. If they find themselves obliged to continue with low-grade extensive agriculture, the tendency will be to spread to the farthest corners of what are now natural (little disturbed) environments. If, on the other hand, they are enabled to practise efficient intensive agriculture, they could make sustainable productive use of relatively limited sectors of their countries, with reduced impacts on wildlands.

52. 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 should be paid by conservationist to these broader perspectives of land use in the Third World, as to narrowly focused campaigns to safeguard threatened species. To reiterate a familiar theme: conservation and development must operate hand in hand. We shall return to these issues later in this Chapter. Let us meantime note that our attempt here to define the problem in its full scope points us toward an adequate resolution - by contrast with most save-species responses to date, which, being essentially reactive, never manage to "get ahead of the game." Indeed, they fall further and further short of what is required. Yet, the established conservation strategies, known as a "fire brigade" approach, are still firmly in vogue in most conservationist circles. Until the problem itself is understood, rather than its

symptoms, there will be no sufficient-scope resolution of the species crisis. Hence this emphasis on our understanding of the ultimate problem and its underlying nature.

53. 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 per cent of its 240 million people occupying only 2 per cent of its territory, at least as many would be living off the land, and over-loading natural environments on every side. Hordes of land-hungry peasants would be clamouring 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?

54. 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 6 per cent of its territory as parks and reserves in order to protect its wildlife and threatened species. Kenya's present population of 20 million people is pressing so hard on protected areas that the three leading conservation units are losing portions of territory to land hunger. Yet, Kenya is theoretically projected to reach a total of more than 150 million people before its population growth stabilizes in the year 2115.

55. The prospect, then, for Kenya's parks must be considered bleak. Similar population pressures threaten parks in Uganda, Ethiopia, Zimbabwe, and several other countries in which the impoverished peasantry is forced to depend one adwindling natural resource base.

Protected areas in these countries may well 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 by the end of the first quarter of the next century. The situation is particularly severe in sub-Saharan Africa because of 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.

2. Developing-World Poverty

56. We see, then, how poverty reinforces the detrimental impact of population build-up. Few people cause greater injury to natural environment 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 billions by the time the developing world's population comes close to levelling out at around 9 billion in the year 2100.[67/]

57. The subsistence peasant is often conscious of the fact that by altering soils, grassland and forests he is jeopardizing the resource base which ideally should provide him with a livelihood for an indefinite period of time. Yet, the urgent food requirements of the short-term preclude realistic conservation measures.

58. 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 all round. The Green Revolution now permits many farmers to make much better use of their croplands. But because of associated socio-economic 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.[68/] Similarly, plantation agriculture, while making intensive use of croplands, often serves to leave multitude of farmers landless.[69/] 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 peasantly as "free" lands available for unimpeded settlement. They can also include woodlands, with their diverse wildlife, savannahs with their rich arrays of beribores, montane zones with their concentrations of endemic species, and wetlands (both coastal and inland water bodies) with their unique communities of species.

3. Developed-World Consumerism

59. After the subsistence farmer, the agent who is next most inclined to environmental destruction is the person at the other end of the "welfare scale", the super-affluent person who seeks more goods at "fair" prices. For example, communities in North America, concerned about increases in the cost of beef, have fostered, albeit unwittingly, the deforestation of Central America in order to supply ostensibly cheap beef for fast foods such as hamburgers.[70/] Beef seekers in Western Europe also stimulate deforestation in Thailand through

marketplace demand for inexpensive food supplements in the form of cassava for feed-lot cattle. These economic-ecological 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.

60. Thus the problem of species extinction reflects growth in both human numbers and human consumerism. This aspect of the situation is accorded less than due attention by persons preoccupied with the basic issues of population explosion. Again, there is a premium on proper appraisal of the intrinsic problem.

VI. NATIONAL ECOSYSTEMS OF INTERNATIONAL IMPORTANCE

61. Let us now move on to examine a further critical dimension of the situation. Once more, we shall find that detailed analysis of the problem points the way toward scope for action. This time we shall look at notions of rights and interests in species, together with closely related concepts of sovereignty and stewardship.

62. Species and their genetic resources plainly supply benefits to all humankind. Wild germplasm from Mexico and Central America serves the needs of corn growers and consumers right around the world. The principal cocoa-growing nations are located in West AFrica, while the genetic recourses on which modern cocoa plantations depend for their continued productivity are found in cocoa's original source areas, the forests of western Amazonia. The principal banana-growing nations are in Central America and the West Indies, while the genetic base is located in the forests of Southeast Asia. The same applies for wheat germplasm, and the genetic underpinnings of barley, rice and coffee, among other

leading agricultural crops. And the same holds good too for startpoint materials that lead to the manufacture of antibiotics, tranquillizers, anti-cancer drugs, contraceptive pills, and other items in the health field; in the industry and energy fields too.

63. This all raises some fundamental questions about heritage concepts. The most critical question of all is: whose heritage? As we have seen, at least two-thirds of all species, and a still larger proportion of genetic variability, occur in the tropics, which means (roughly speaking) the Third World. By contrast, the developed world, depauperate as it is in biological diversity, possesses the technological capacity to exploit species and their genetic resources for economic advantage. This situation raises several issues salient to relations among the community of nations in general, and between North and South nations in particular.

64. The heart of the matter lies with the idea of species as property. To whom, for example, does the ayeaye of Madagascar belong - or "belong"? As a form of primitive primate, it is endemic to Madagascar; and it thereby comes under the sovereign jurisdiction of Madagascar. At the same time, however, this acutely endangered species can surely be regarded as a subject for acceptable concern on the part of the rest of humankind - especially if it were to provide (as has the cotton-topped mormoset of Brazil, among other primates) a critical research model for study of cancer. Similar considerations apply to the other 18 species of lemur in Madagascar, a special group of primates, probably with special insights into fundamental aspects of biology, evolution, physiology and the like; and all of them are threatened.

65. In the light of this situation, we can surely venture a view to the effect that the Earth's stocks of species and genetic variability constitute part, in some senses at least, of the common heritage of all persons now alive on Earth, plus all future generations. They can hardly, in equity, be deemed to be the sole exclusive concern of nations within whose territorial boundaries they happen to exist. Each citizen of Madagascar enjoys his or her share in the planetary patrimony of species and genetic resources every time he or she takes a cup of coffee: without wild relatives of the coffee plants, principally located in Ethiopia, plus their germplasm contributions to the coffee crop in a dozen producer countries, a Madagascar citizen would be contemplating the one-dollar cup of coffee. In turn, Ethiopia enjoys concessionary supplies of grain and other relief food from North America, thanks to the exceptional productivity of the great grain belt across the United States and Canada - which continues to flourish, and even expand its bounty year by year, by virtue of corn and wheat genetic resources from Central America, the eastern Mediterranean and other centres of genetic variability. Brazil, which supplies wild rubber germplasm to Southeast Asia's rubber plantation (and like Ethiopia, is growing increasingly wary of traditional approaches to trade in wild genetic resources), depends on unimpeded access to germplasm supplies in diverse parts of the world in order to sustain its sugar-cane, soybean and other leading crops. Without access to foreign sources of fresh germplasm year by year, the nations of Europe would quickly find their agriculture declining in output.

66. The illustrations are drawn from the field of agriculture, especially crop agriculture. We can draw similar parallels with regard to livestock husbandry, medicine, industry, and other major economic sectors.

67. In addition, a citizen of Europe may feel his life would be impoverished on aesthetic grounds, if he were to hear that the California condor had become extinct. An American may feel the same if he heard there were no more Tasmania wolves. An Australian may feel the same again if he were to find there were no more ayeayes left in Madagascar. And a Madagascarene may feel he has lost something of intrinsic value if the blue whale were finally to fade into oblivion.

Rights and Activities: Exclusive and Inclusive

68. In these circumstances, a central problem - and a major opportunity - lies with rights and activities of nation-states. These rights and activities can be either exclusive or inclusive. Herein lies a basic issue of international law - and like the concept of sovereignty, it is in a state of flux, however little that fact (fact of daily life, not theory of jurisprudence lore) may be recognized by certain sectors of the global community.

69. "Exclusive" refers to those rights and activities that affect predominantly only one nation. The term is thus associated with national independence. "Inclusive" refers to those rights and activities that have significant effects for other nations, sometimes known as "externality effects". Thus, the term links up with interdependence. By implication, "inclusive" refers especially to those resources that are, in whatever degree, resources of common heritage. Examples include not only species concentrations and their habitats/ ecosystems, but the oceans and other major water bodies, marine fisheries, rare geomorphological features, and the planetary air mantle. Species concentrations and important ecosystems clearly belong to individual nations on the grounds that they are located within territorial jurisdictions. Equally clearly, they are of legitimate interest to the community at large.

70. This, then, is the dilemma of rights and activities of nations with regard to threatened species and exceptional-value ecosystems. Due to their outstanding importance for the whole community of nations, these natural resources deserve to be maintained, in some senses at least, as shared resources under inclusive competence, as free as possible from exclusive competence or dominance. Thus species straddle both exclusive and inclusive concepts - a situation that raises complex difficulties for their ultimate conservation. Were a tropical-forest nation to cut down a sector of its forests that includes the sole habitats of myriad species, could this not be construed as eliminating an integral component of the planetary ecosystem, and thus inflicting a degree of environmental injury on all nations?

71. Indeed, the time may be coming when the Earth's endowment of species, as high-value resources, will be seen as an asset to be conserved and managed for the benefit of all humankind (provided the legitimate needs of the native home country are met). This will mean that the community of nations will have to reconsider what is implied by ownership, use, and allocation of these resources - plus what can be undertaken in the way of expanded safeguards for them. This will be a tough and virtually unprecedented challenge. Yet some measures along these lines may become necessary as humankind becomes ever-more ready to exploit species and their genetic resources for economic purposes.

72. In sum, the challenge of conservation of species, and of their ecosystem habitats, deserves to be a special concern of the global community. This implies two forms of responsibility: highly compelling responsibility, considering what is at stake. First, any nation faces a duty to offer whatever support is required - finance,

skills, etc. - to enable individual nations to discharge their duties. We shall now go on to consider how this responsibility can be better discharged in practice.

VII. SCOPE FOR INTERNATIONAL ACTION

73. We have seen that all humankind will suffer through mass extinction of species, if only through the utilitarian benefits foregone. This argues that everybody should share the responsibility of relieving the problem. The situation postulates efforts by institutions, at both national and international levels, of a scope and scale that reflect the increasingly interdependent character and needs of the global community.

74. A first priority in addressing the issue of disappearing species is to establish the problem on political agendas as a strategic resource issue. We might well consider formal policy commitments on the part of Governments, also in international forums, such as the United Nations General Assembly. Further, we could create a species trust convention, with funding supplied by the community of nations, in recognition of the principle that species constitute resources of common heritage, to be maintained on behalf of the global community now and forever. Collective responsibility for the common heritage would not mean collective rights to particular resources. Far from playing down sovereignty, this approach would emphasize it as a functional concept. A nation would no longer be left to rely on its own isolated efforts to protect its species, but could look for assistance from the community at large.

75. How large might such a trust fund have to be? Various estimates have been bandied about, ranging from a mere $200 million to $2 billion a year. As we have seen above, the cost of expanding the present network of protected areas until it takes care of most (though not all) species would probably run to something in the region of $1 billion a year for at least 10 years; after which the costs of running and maintaining the areas would be substantially less. Let us recall, however, that the present network of protected areas of all kinds, grossly inadequate as it is to meet even present needs, will fail in large part to measure up to the new needs of a warming-up biosphere. To devise the network of protected areas that the world will presumably need by the year 2050 will require much larger areas brought under some degree of protection; plus a sophisticated degree of flexibility in management techniques for protected areas.[71/] All in all, the cost for protected areas to serve long-term needs could rise to $2 billion, even twice as much - a figure that is advanced as a very preliminary and approximate assessment of needs, calculated merely as a way for us to start to get to grips with a key aspect of longer term species conservation: nothing more.

76. On top of all this, further funds will be required for conservation activities outside protected areas, such as wildlife management of various sorts, education campaigns, etc. But these are little likely to be expensive as compared with establishment of protected areas.

77. Of course, the figures proposed above are no more than "inspired guesstimates". They are far from substantiated or systematized estimates, even though it is believed that on the basis of exploratory discussions with development agencies and conservation organizations,

that the higher figure may well be in the right "ballpark". Meantime, it is an indication of many conservationists' mind set, stuck as it is with a fire brigade outlook, that nobody has yet tried to come up with an objective assessment of costs of a comprehensive save-species campaign.

78. Meantime, we should consider some further measures of more sharply focused while less expensive scope. Foremost could be a strategy directed at conservation of wild gene reservoirs of special significance. A probable mechanism would be "genetic conservation areas" in those countries most endowed with genetic resources. The entry points for institutional initiatives could be two-fold. First, individual countries could engage in land-use planning, and in environmental planning generally in a manner that takes specific account of gene conservation needs and opportunities; and they could explicitly incorporate their genetic resource stocks into their systems of national accounting. Secondly, international agencies could give much greater attention to the problems and challenges of gene conservation through their aid and investment policies and programmes.

Some Initiatives Underway

79. A number of measures have already been attempted at international level. They are very limited in scope, only partially successful, and essential reactive in character. The principal United Nations agency in this area, UNESCO, operates a project on natural areas and genetic resources. But is is no more than a clearing-house for information. In addition, its World Heritage Fund supports a handful of exceptional ecosystems around the world. Both these activities receive trifling budgets. UNESCO further seeks to establish a global system of Biosphere Reserves

representing the Earth's 200 biotic provinces: the Reserves would harbour sample communities of species. But only one third of the Reserves have been established, even though instituting and operating the rest would cost only about $150 million a year.

80. Other U.N.agencies, notably FAO and UNEP, run programmes with regard to threatened species, genetic resources and outstanding ecosystems. But their combined activities do no more than make a preliminary dent in the problem. As for bilateral agencies, the U.S. Agency for International Development leads the field in recognizing the value of species conservation. Legislation being considered by Congress could shortly make available a sum of between $2 million and $10 million a year for this purpose - again, a solid gesture as compared with what has been done to date by bilateral agencies, a trifling gesture as compared with needs and opportunities.

81. Although citizen conservation groups have made some sizeable contributions, they have been unable to attract nearly sufficient funding from the general public. The World Wildlife Fund, working in conjunction with its scientific arm, the International Union for Conservation of Nature and Natural Resources (IUCN), has been able to mobilize rather more than $120 million since its founding in 1961. Another gesture: nothing less, nothing more. At the same time, of course, let us note that these two bodies, like many other NGOs, make highly efficient use of each scarce conservation dollar.

82. This dismal record confirms that the species problem tends to be perceived largely in scientific and conservationist terms, rather than as a leading economic and resource issues. As such, it lacks political clout. What is needed is a campaign of sufficient scope to confront the problem overall. To repeat the central

point, the time is sure coming, or has already arrived?, when we need to formulate substantive support programmes at international level, as a measure to reflect collective responsibility on the part of the community of nations for a deteriorating asset of common heritage.

One encouraging development in the last year has been the global Tropical Forestry Action Plan, a collaborative effort involving the World Bank, UNDP, FAO and the World Resources Institute. This broad-based effort is resulting in the development of national forestry sector reviews, national forest plans, identification of new projects, better co-operation between development assistance agencies, and increased flows of technical and financial resources into forestry and related fields. The conservation and improved management of major tropical forest areas are integral parts of the global Action Plan, and it is widely recognized that conserving tropical forests will protect a major part of the world's flora and fauna.

83. While the matter of funding is of paramount importance, so too is the question of norms and procedures with respect to resource issues. At least three precedents arise: the Convention on Wetland of International Importance, the Convention on Conservation of Islands for Science (both of which safeguard prime habitats with their species concentrations), and the Convention on International Trade in Endangered Species. All these three precedents help with the situation; yet if they were twice as effective and three times as numerous, they would make no more than a marginal contribution to resolving a problem that rapidly grows worse. They are essentially reactive, an attempt to devise "species refuges" in face of the advancing tide. What we need to do is find ways to hold back the tide, or even to send it off in another direction. To do that, we

need to know more about the nature of the tide, its origins, its dynamics, and so forth. Then we can start to get to the root of the problem. We shall consider this further in the next section.

84. In conclusion to the present section, let us reiterate that the threatened-species issues highlight the interdependent nature of society at large, and the need for collective action on the part of the community of nations. A communal effort to safeguard species might help induce a spirit of international co-operation necessary in addressing broader international issues, notably economic and resource issues. Indeed, a campaign in support of threatened species could help articulate the common interest of nations; and it might even encourage Governments to adopt a more collective approach to other international issues, leading to an enhanced world order.

85. Meantime, let us also reiterate that what is proposed here is a collective commitment on the part of all nations, on a scale that reflects the increasingly interdependent character and needs of the global community. Whether the global community perceives itself as a community or not, it functions as such in many of its ecological relationships and economic interactions. And the community will sooner or later be obliged to make collective response to the problem of disappearing species: either sooner, through safeguard measures of sufficient scope, or later, when it findd that the disappearance of large numbers of species represents a loss through which all nations will be indivisibly impoverished, forever.

VIII. HARMONIZING ECONOMIC GROWTH AND SPECIES CONSERVATION

86. The present approach to species preservation is for the most part a defensive reaction that seeks to set aside parks and reserves, rather than to alter development patterns to make them more compatible with the preservation of biological diversity. Yet, unless economic and land-use forces are re-channeled, the last endangered bastions of wild resources will eventually be besieged and overrun.

87. Fortunately, there is much that can be done to help the situation. Not only can Third World governments stem the destruction of tropical forests and other reservoirs of biological diversity without sacrificing economic goals. They can conserve valuable species and habitat while at the same time reducing their economic and fiscal burdens. Ironically, it is often government policy, not economic necessity, that drives the over-exploitation and destruction of these resources; and the direct economic and fiscal costs - in addition to those of species extinction - are huge.

88. For example, many tropical countries with large forest resources have provoked wasteful "timber booms" by assigning harvesting rights to concessionnaires, domestic and foreign, for royalty, rent, and tax payments that are only a small fraction of the net commercial value of the potential log harvest. They have compounded the incentive by offering only short-term leases, requiring concessionnaires to begin harvest operations at once, and adopting royalty systems that induced loggers to "high-grade" the forest, harvesting only the best trees and doing enormous damage to the remainder. In response to the opportunities for quick profits, logging entrepreneurs in several countries have leased virtually

the entire productive forest area within a few years, over-exploited the resource with little concern for future productivity, and opened it up for subsequent clearing by slash-and-burn cultivators.[72/] The result has been extremely wasteful exploitation of those tropical forests, sacrificing most of their timber and non-timber values, enormous losses of potential revenue to the government and the national economy, and - at the same time - destruction of rich biological resources. Reforming forest revenue systems and concession terms could raise billions of dollars of additional revenues, promote more efficient, long-term forest resources, and curtail deforestation.

89. This is but one example of complementarity between the goals of economic development and species preservation. Another example comes from Central and Latin America, where many governments have strongly encouraged large-scale conversion of tropical forests to livestock ranches. Many of these ranches have proven to be unsound, both ecologically and economically, because without intensive management the underlying soils are soon depleted of nutrients, weed species replace planted grasses, and pasture productivity declines abruptly. Yet tens of millions of hectares of tropical forest have been lost to such ranches, largely because government policies have underwritten the conversions with large land grants, tax credits and holidays, subsized loans and other inducements. In such countries, governments could save themselves enormous expense and revenue loss, promote more sustainable land uses, and slow down the destruction of tropical forests by eliminating such incentives.[73/]

90. Many other opportunities can be found to modify current government policies in Third World countries to encourage both species conservation and economic productivity. For example, many governments maintain

unrealistically low taxes on rural land, geared to its actual rather than to its potential productivity, while allowing settlers to establish title to "virgin" lands by converting it to cropland or pasturage. As a result, wealthy landowners are enabled to keep huge, under-utilized "latifundia" at little or no cost, while land-hungry peasants are encouraged to go into the forest to establish marginal holdings. Tax or tenure reform, or both, would induce the fuller realization of potential productivity on existing holdings in these countries, and reduce the pressures to expand cultivation into forests and upland watersheds.

91. The most notable instance of policy-driven deforestation at international level is the promotion of tropical timber imports into Japan and other industrial countries, through tariffs, trade restrictions, and domestic forest policies. Industrial countries typically allow imports of unprocessed logs from tropical countries either duty-free or at minimal tariff rates, while imposing much higher tariffs and import restrictions on processed wood products. The effect is to encourage local industries to use logs from tropical forests rather than their own timber resources, and this effect is reinforced by domestic restrictions on the allowable cut. Japan, for example, buys three-quarters of all hardwood exports from Southeast Asia, a region undergoing rapid deforestation. It could supply its entire hardwood needs from Japanese forests, since two-thirds of the country is covered with good quality forests. Yet, annual removals from these Japanese forests have been reduced by half over the past 20 years in the interests of domestic conservation goals, and are now much less than annual growth.

92. As with tropical deforestation, so with the spread of deserts, and the elimination of dryland species. Arid and semi-arid zones harbour only a very small number of species as compared with tropical forests. But because of the species' remarkable adaptations to harsh living conditions, they feature many unique biochemicals, such as the liquid wax of the jojoba shrub and the natural rubber of the guayule bush. While scientific inventories and economic evaluations are scant as concerns dryland species in Southern Africa, we can note that the region harbours 20,000-plus plant species, over half of them endemic and most of them dryland species, almost 2400 of them are under threat. Within the region, consider the specific case of Botswana, a country that dispatches more than half its beef output overseas, two thirds of which goes to the EEC. While the Community possesses a surplus of grain-fed beef, it suffers a shortage of lean, i.e. grass-fed beef. So through its development-aid programmes, it heavily subsidizes the beef-export trade in Botswana. As a measure of the impact on species, wildebeest, which used to total many hundreds of thousands, have now dwindled in numbers, through loss of habitat, until they now total only 10 per cent of their once vast herds. A similar process of savannah degradation and wildlife depletion can be seen in several other African countries, where the spread of cattle ranching is subsidized by the EEC, notably in Kenya, another country with exceptional arrays of wild species.

93. So too with the spread of desert in the Sahel.[74/] Despite its droughts, the Sahel continues to grow more agricultural produce year by year. But most is made up of commodities for export, rather than food for local consumption. The cash-crop trade is upheld by virtually all Sahelian governments on the grounds that it attracts support from development-aid programmes and commercial investment from Europe. In 1984, the Sahel

grew almost seven times as much cotton as in 1961, and it imported almost nine times as much cereal grain. Because of the expansion of large-scale cotton plantations, also those of peanuts, hosts of small-scale farmers have become sidelined from the development process. These marginal people move off into marginal environments, i.e. lands with soils too dry and friable for sustainable agriculture, whereupon their activities quickly turn semi-arid lands into desert.

94. All this is not to say that exports of commodities from the developing world to industrial countries should be discouraged. In fact, too often developing countries have penalized commodity exports through overvalued exchange rates, export taxes, and levies imposed by crop marketing boards, severely restricting returns to farmers and production urgently required to earn badly needed foreign exchange. There is no general tendency for exportable crops to be more environmentally damaging or demanding than subsistence crops. Many export crops are perennials and tree crops, which, when grown with grasses underneath, afford better protection against soil erosion than row and root crops like cassave, maize, and millets. What is essential is that all crops be grown on suitable soils using appropriate techniques.

95. Finally, let us revert to the factor that has already been described as probably the single greatest threat to the save-species cause in the foreseeable future, and that is climatic change as a result of build-up of carbon dioxide among other "green house gases" in the global atmosphere. The climatic dislocations this will surely entrain will not become apparent until the start of the next century. Yet right now we are losing valuable time for taking ameliorative counter-measures: we shall not again have so much manoeuvering room. Moreover, we have seen that many

broad-scope decisions as concerns protected areas are being taken right now on the assumption that climatic patterns of the future, vegetation zones too, will be a simple continuation of the past. Yet, there is gathering evidence that this will be far from the case. While delay in response will cost us dearly in many ways other than the cause of threatend species, let us bear in mind that corrective action taking ahead of time, i.e. forthwith, can make a surprising difference in the way of reducing climatic dislocations. Of course, the reasons for taken these adaptive policy initiatives have to do with factors of energy production and consumption, not with disappearing wildlife. We can rarely make progress on one front without making progress on other fronts as well.

96. These few examples of the role of policy factors in save-species efforts serve to illustrate the broad scope that awaits imaginative policy makers and development analysts. We can surely find many more such instances if we adopt the appropriate mind set - which is a world away from the "tried and found wanting" strategies of conservation to date. An effort to tackle any one of the policy factors listed would surely yield much more for species conservation than all the measures of the past ten years in support of park building, ranger patrols, anti-poaching units, and the other conventional forms of "wildlife infrastructure". It can hardly be stressed strongly enough that the present approach to saving species, even were it to be expanded several times over, will become less and less able to withstand the flood of human throngs and human activities that threatens to overtake wildlands on virtually every side - unless we can do more to divert the flood, not merely resist it. After all, the population build-up from 1950 to 1985 added only 2.3 billion people to humankind, whereas the build-up from 1985 to 2020 is projected to add another 3

billion: hard pressed as wildlands already are from multitudes of land-short people, the main population explosion is still to come. While parallel figures for expansion of economic activity are not available for the precise periods cited, we expect that the global economy may well grow five times over during the next half century, which suggests much more economic activity in the 35 years ahead than in the 35 years past.

IX. SCOPE FOR NATIONAL ACTION

97. Suppose international support of suitable scale, in the form of a trust fund or some similar mechanism, were to be forthcoming to assist species-rich countries that lack adequate conservation resources. How could the support be best applied at the level of the individual nation? Answer: the same as before, only more so and better so. Whereas we need an altogether new initiative at international level, we need a reinforcement and expansion of existing strategies at national level.

98. There is a plethora of urgent needs: better wildlife management; better protected-area management (with more use of buffer zones); more protected areas of non-conventional types (such as the ecological stations that are proving so successful in Brazil, also multiple-purpose conservation units such as at Ngorongoro in northern Tanzania); more game cropping/ranging projects (such as the crocodile schemes in Zimbabwe, India, Thailand, and Papua New Guinea); more promotion of wildlife-based tourism; and stronger anti-poaching measures (very few species are threatened by poaching, as compared with the vast numbers threatened by habitat loss; this topic is covered in Appendix 2).

1. Priority-Ranking Strategy

99. Two issues of national-level conservation deserve much more attention, and we shall look at them briefly. Every nation has only limited conservation resources at its disposal, viz. finance, scientific skills, and the like. Even if resources were to be increased several times over, no nation could hope to save all its species that appear doomed to disappear: the processes of habitat disruption have already developed too much momentum to be halted in short order. Yet, when a nation allocates funds to safeguard one species, it automatically denies those funds to other species. Already the most conservationist nation supports only a fraction of all its species at risk and, unless far larger funding becomes available, it may soon find itself in a situation where it can assist still fewer in relation to overall needs. How should a nation allocate its scarce conservation resources in the most efficient fashion in order to safeguard the "most worth" species? We have surely reached a stage where there is merit in determining which species are most deserving of continued space on the planet. Agonizing as it will be to make such choices, we need to make our conservation strategy as systematically selective as possible.

100. To reiterate the central factor, we already bestow our conservation resources, and thereby place a premium, on certain species in preference to others. We may choose unwittingly rather than deliberately. But we choose. Why not, then, choose explicitly rather then implicitly -and by design rather than by default? True, a "triage" strategy, as a priority-ranking strategy is sometimes known, means that many hard, even harsh

decisions will have to be made. Nobody cares of the prospect of deliberately consigning threatened species to oblivion. But insofar as we are already doing so, we might as well do it with as much selective discretion as we can muster.

101. A case in point is the California condor in the United States. Reduced to a last few individuals, the condor is reckoned to have no more than a 50-50 per cent chance of survival despite the many millions of dollars that are now being spent on it. Were those dollars to be spent on e.g. freshwater species (at least half of all molluscs in the United States are threatened), hundreds of species could be assisted with virtually 100 per cent chance of success.

2. Integration of Wildlife Conservation with Sustainable Development

102. As we have seen, species conservation strategies tend to be overwhelmed by policies in leading development sectors, such as agriculture, forestry and trade. At macro-economic planning level, this is mainly because species conservation is not perceived as an activity that contributes to the predominant goal of any nation, and especially of a developing nation, viz. economic advancement. This is partly because conservationists have not always "sold" their message strongly enough in terms that development leaders appreciate; partly too because the inherent nature of species conservation tends to be a long-term affair, thus beyond the purview of short- and medium-term planners.

103. Fortunately, there are ways to put over the message in a manner that portrays conservation as a contribution to the new predominant goals of sustainable development. That is, ecosystem conservation rather than species

conservation (not that the distinction matters to species conservation, since ecosystem conservation amounts to habitat conservation). In many instances, one can build a case to the effect that safeguards for critical tracts of wildlands serve also as a support for e.g. agriculture. This applies particularly to safeguards for upland forests of the tropics, with their many watershed functions - and upland forests often contain some of the richest concentrations of species (on the grounds that altitudinal variations comprise a broader array of habitats and a greater range of niches).

104. A case in point is the Dumoga-Bone Park in northern Sulawesi, covering some 3000 square kilometres of upland forest. It contains large populations of most of Sulawesi's endemic mammals, and many of the island's 80 endemic bird species; and presumably a large proportion of endemic plants and associated insects. After an initial reserve was established by the Indonesian Government, it could not muster sufficient support to protect it from incursions by slash-and-burn migrants. In the flatlands downstream, the World Bank had meanwhile established the Dumoga Valley Irrigation Scheme. This project was set up to achieve a three-fold increase of rice production in more then 13,000 hectares of prime agricultural land. Through disruption of the forest cover, however, dependable supplies of irrigation water started to declines; there were threats of flooding for a nearby city, Gorontala; and soil erosion that would lead to siltation of port facilities. So as a measure toward sustainable agricultural development, and with a spin-off benefit for species conservation, the World Bank undertook to upgrade the reserve to a park and to reinforce the safeguards. Result, enhanced viability of

the irrigation scheme, and continued viability for the protected area. All in all, this has proven to be a prime example of a complementary rather than a competitive relationship between ecosystem conservation and food production.

105. A number of similar examples can be cited. The Canaima Park in the Amazonian sector of Venezuela, for example, protects domestic and industrial water supplies for the capital city of Caracas, and for a major hydropower facility. In similar sense again, we can perceive a mutually-sustaining relationship between species conservation and agriculture, in terms of protection of wild gene reservoirs. As we have seen at various points in this Chapter, one of the best hopes for species survival lies with intensification of agriculture in established farmlands, thus reducing incentive for otherwise landless cultivators to encroach on wildlands. One of the best ways to intensify agriculture in many developing countries, notably those in the humid tropics, is to foster stabilized (as opposed to migratory or shifting) cultivation, on a permanently productive basis. One key to this approach lies with polycultural agriculture; and increasingly the key to this lies with adaptive variations of multiple crops, that in turn derive their genetic variability from wild gene reservoirs, sometimes protected within parks.[75/, 76/, 77/] In other words, the one strategy supports and sustains the other.

106. To this extent, we can postulate a theme of "parks for development", insofar as parks serve the dual purpose of protection for species habitats and development processes at once. The conceptual strategy is somewhat new for the conservationist community. But it does not supplant erstwhile approaches, rather is serves to strongly supplement them. In short, it is an approach that deserves to be thoroughly explored and expanded.

X. THE ISSUES AWAKING: SIGNS OF HOPE

107. In face of a bleak situation, there are signs - a few signs, no more and no less - that this long-asleep issues is awakening. At last, at long glorious last. While the extinction threats have been growing larger faster, so too has public awareness been growing apace around the world. Mass extinction of species is no longer seen as a preoccupation of cutesy-creature enthusiasts. It is starting to be perceived as a phenomenon that carries pragmatic implications for all citizens around the world, now and for generations to come.

108. A few examples illustrate the outburst of public awareness. In Kenya, the Wildlife Clubs have gone from strength to strength since their start-up in the late 1960's, until the networks of school clubs now total more then 1300, with around 70,000 members. A parallel development in conservation education has occurred in Zambia. In Indonesia there are some 400 conservation groups of one sort and another, and they have banded to gather under the banner of the Indonesian Environmental Forum until they exert sizeable political leverage. In

the United States, membership of the World Wildlife Fund has expanded from 58,000 in 1981 to 172,000 in 1985, while annual donations have soared from under $4 million to almost $14 million.

109. In response to this broad-scale grass-roots interest, Governments have been moving to help their threatened species. They have been doing so primarily through additional protected areas. Today, the worldwide networks total more than 4 million square kilometres, roughly equivalent to the United States east of the Mississippi. Since 1970, the networks have expanded in extent by more than 80 per cent, around two-thirds of which in the Third World: a move in the right direction, albeit leaving a long way to go.

110. It is the new-found interest of Governments that is specially encouraging - and, let us note, especially on the part of the Government of the United States, which has been something of a front-runner in the species-conservation field. In 1980, U.S. Secretary of State Edmund Muskie asserted that the question of genetic resources, among other environmental issues, should be considered a matter of paramount importance among the community of nations. In 1981, the State Department convened an International Strategy Conference on Biological Diversity (meaning biological depletion). In 1983, Congress passed the International Environment Protection Act, which requires the Government, through its foreign aid programmes among other activities, to take special account of species communities and gene reservoirs around the world. Congress continues to pursue the issues through further legislative measures - the only developed nation to take measures of this type and extent.

XI. CONCLUSION

111. By comparison with the needs of the situation, these various initiatives and activities can all be viewed as far too little and far too late. But it is a start - at at least a start on a start - toward recognizing one of the great sleeper issues of our time, and seeing it in its proper scope. There is the first glimmering of an idea among the public at large, that we are becoming unwitting witnesses of the greatest enduring intrusion we can make in our biosphere, short of all-out nuclear war followed by all-out nuclear winter. And whereas nuclear war still remains only a possibility, mass extinction is fast becoming a fact. Of all the environmental assaults we are imposing on the biosphere, mass extinction will amount to the most pervasive and profound, and by far the most prolonged. After all, and to reiterate a key point, it is intrinsically irreversible, which puts it in a class apart from deforestation, desertification and other major environmental assaults. A mass-extinction episode of the sort now underway will not be made good for millions of years, perhaps tens of millions.

112. Until very recently, furthermore, we have remained more indifferent to mass extinction than to any other environmental assault. All the more, then, we can now take credit for starting on a response to the situation. If the prospect of a suitable-size response seems daunting, we should remind ourselves that the first great waves of extinctions are only beginning to wash over the Earth's biotas. There is nothing inevitable about a mass extinction ahead of us. We can still save species in immense numbers.

APPENDIX 1

SPECIES AND GENETIC VARIABILITY

113. As indicated in the main text, there is much genetic variability within species. A typical bacterium may contain about 1000 genes, certain fungi 10,000 and many flowering plants and a few animals 400,000 or more.[79/] A typical mammal such as a house mouse may harbour "only" 100,000 genes, a complement that is to be found in each and every one of its cells. As has been graphically expressed by Professor Edward O. Wilson of Harvard University:[80/]

> "Each of the cells (of the house mouse) contains four strings of DNA, each of which comprises about a billion nucleotide pairs organized into a hundred thousand structural genes. If stretched out fully, the DNA would be roughly one metre long. But this molecule is invisible to the naked eye because is is only 20 angstroms in diameter. If we magnified it until its width equalled that of the wrapping string to make it plainly visible, the fully extended molecule would be 600 miles (m?) long. As we travel along its length, we would encounter some 20 nucleotide pairs to the inch (cm?). The full information contained therein, if translated into ordinary-sized printed letters, would just about fill all 15 editions of the Encyclopedia Britannica published in 1786 (?)."

114. Each species, then, constitutes its own stock of genetic diversity, and virtually all species harbour a far greater amount of genetic variability than is suggested by the concept of species alone. Not only does a species comprise a number of sub-species, races and

populations, each of which constitutes a distinctive reservoir of genetic material. All the organisms that go to make up a species are genetically differentiated, due to the high levels of genetic polymorphism across many of the gene loci (except in cases of parthenogenesis and identical twinning).[81/] The 10,000 or so ant species that have been identified are estimated to comprise 10^{15} individuals at any given moment.[82/] All the more, then, the total number of species is not the only standard by which we should evaluate the abundance and diversity of life.

APPENDIX 2

POACHING

115. In only a few instances is poaching a serious problem. But in certain of these instances, it is a super-severe problem. In the case of the African rhino species, the price of horn has increased from $30 per kilogramme in 1970 to $750 in 1985; and in the case of the Asian rhinos, from $1400 to more the $8000.[83/] In 1970, there were still around 15,000 black rhinos in Africa, but by early 1975, there were fewer than half as many; while the northern white rhino has declined from almost 1000 to one dozen at most.

116. As for the African elephant, the price of ivory has risen from $3 per kilogramme in 1970 to more than $50 in 1985, and the volume exported from Africa now runs at around 1000 tons a year (an average elephant carries only 10-12 kilogrammes of ivory).[84/] Let us note, however, that if the trade in ivory were to come to a halt forthwith, elephant numbers would soon start to decline again, surely within 5-10 years, in most of the range in savannah Africa, due to steady loss of habitat in face of the highest population growth rates anywhere in the world - growth rates which appear set to carry on increasing until the end of the century or so.

117. Meantime, the best response to the poaching problem is well known: cut off the markets of product sale. This is much more effective (while perhaps less glamorous?) than marching poachers off to jail.

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