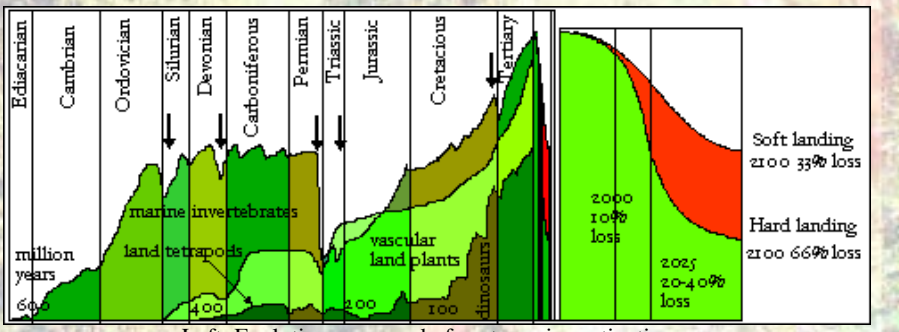
Whirinaki Forest New Zealand saved from logging by protesters 1984 (Morton, Porritt 93). Several New Zealand forests have been saved from logging by sit-ins by Native Forest Action. Hauturu Rata - Don Binney The birds are the kakariki, popokatea and endangered stichbird. New Zealand forests and fauna are unique because of their isolation (Porritt). There were no land mammals and many forest species are adapted to native bird pollination

Sacrifice of Eve: Extinction of Biological and Genetic Diversity

Destruction of wildlife habitats and their genetic and species diversity is a threat to civilization second only to thermonuclear war. Life on Earth could, at best, take millions of years to recover. Despite the promises of the Rio convention, yetas yet unratified by the U.S. the forest is burning up to 34% faster and the seas are being over-fished. In the next 25 years, if we don't take decisive action, the greatest species extinction for 200 million years will in all probability occur - an irreversible loss, which will severely compromise both the future prospects of humanity and the evolutionary potential of the biosphere, for which we will be condemned by our descendents for millennia to come. There is still time to turn the tide of ignorance and inertia for the future of life, but we need to act very quickly to create a watershed of human conscience.

The current mass extinction is different from previous ones, because it is we who are causing it, despite our supposed intelligence. Previous extinctions are believed to have been caused by large astronomical impacts. A putative crater has been found in Yucatan for the Cretaceous-Tertiary event 65 million years ago, which wiped out the Dinosaurs and a similar event has been attributed to the Permian extinction 220 million years ago where up to 96% of hard-shelled marine species died. Longer-term massive volcanic formations mave also played a role.. Notably the Deccan traps are opposite Yucatan so could be part of the same phenomenon. The Permian extinction was associated with a massive shrinking of the oceans and then a resurgence, severely disrupting the shoreline ecosystems. Another sugges-

tion about the Permian extinction is that a nearby supernova disrupted the magnetosphere and ozone layer irradiating life. Chaotic population fluctuations have also been suggested to play a part in extinctions and even the earth passing through a region of dark matter has been suggested as an alternative source of volcanic disruption.



Left: Evolutionary record of past species extinctions.
Right: Hard and soft landings in the 21 st. century vary between 1/3 and 2/3 (King).

Evolution is a process of change and species extinction is as natural as the emergence of new ones. During the history of Earth, many more species have existed than remain on earth today. However today a single species, man is causing a mass extinction whose probable significance is at least the fourth biggest in history. The extinction rate is phenomenally increased and has been gathering pace over the last ten thousand years to a dizzy peak this century and next.

Left: The Kiwi is New Zealand (Aotearoa's) national symbol. It currently numbers in the tens of thousands, but this fundamental aspect of our identity is due to disappear from the mainland sometime mid next century. Right: Kereru. This bird is a keystone species for up to seventy species including major large seed forest species yet it is being driven to extinction by Maori poaching as a traditional food and rat, and opposum predation. The future fertility of the forest now remains in doubt. Over 30% of New Zealand native birds are endangered, compared with 12% worldwide, partly as a result of its unique and isolated ecosystem with many flightless birds (NZ DOC).

Humankind has altered its environment for millennia, causing some domesticated and weedy species to prosper but many others to suffer, especially good sources of food such as the large land animals. In some ways this has been of great benefit to humanity, through the global spread of crops and domesticated animals around the world. But it has also led to catastrophic extinctions. A vast majority of large spe-

cies of mammals and birds in several continents and islands including the Americas, Australia, New Zealand and Madagascar died out about 10,000 years ago at the hands of the first humans to migrate into these regions (p 969).

The Conflagration of Genetic Diversity

A million species may have died out during the last century, but even this is msay have been a vast under-estimate because the number of uncharacterized species in many small species, from insects to bacteria, may exceed the known ones by an order of magnitude. It is hard to be accurate about extinction rates, since most go unrecorded; the vast majority of the world's species have neither been named nor classified, but this unsureness is a cause for caution rather then neglect.

By the year 2050, half of all the species alive today could be lost forever. The disaster threatens to surpass the mass extinction of 65 million years ago when the dinosaurs disappeared. The causes are diverse, but they all come down to human impact without foresight. Over-hunting and over-fishing, pollution and the trade in wildlife all play a part. But by far the greatest cause of the extinctions is the destruction of wild habitats for farming, fuel, industry and a host of other uses. David Attenborough in his 2001 series "The State of the Planet" lists five principal causes habitat destruction, over-harvesting, islandization, pollution including sudden global warming and the transfer of moxious species..

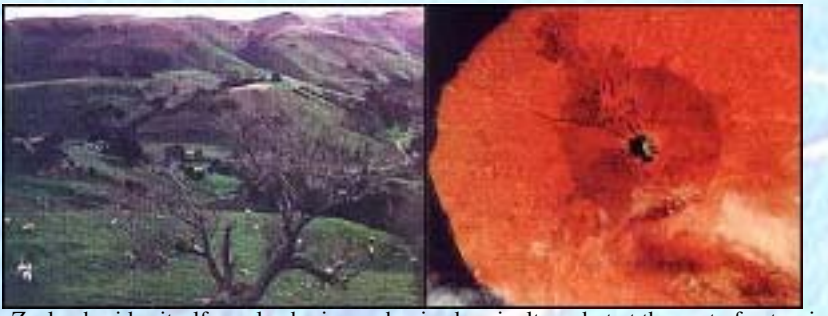
There are more insects in the world than any other group of organisms. Until recently, virtually all the natural medicines we have developed have come from plants and fungi, but a sector which produces both cochineel and potent stinging toxins cannot fail to have diverse biochemicals. Currently only about 20% of all insect species have been identified, let alone chemically characterized. Yet the diverse insect species could be rapidly decimated before they are characterized with the destruction of natural habitats.

Total species number estimates. It is hard to know how many undiscovered species remain. Insect species outnumber all others and may contain many unexplored drugs and medicines. 1996 estimates of 80% undocumented insect species would put the world species at about 7 million (Lean 128).

	Number identified	% of estimated total
Micro-organisms	5,760	3 – 27%
Invertebrates	1,020,561	
Plants	322,311	65 – 100%
Fish	19,056	83 – 100%
Birds	9,040	94 – 100%
Reptiles and amphibians	10,484	90 – 95%
Mammals	4,600	
TOTAL	1,392,488	
	Number of species	% yet to be identified
Low estimate of all species	4,443,644	69%
High estimate of all species	33,526,824	96%

The world's tropical rainforests, which contain at least half the world's species, are falling fast: Little more than half of the original expanse of the Amazon still remains and the forests of South East Asia and the Congo have already been severely depleted. An area as big as Romania is cleared each year. The temperate forests are likewise under siege. Half the world's wetlands - other abundant habitats - have been drained or developed and species-rich coral reefs are being destroyed throughout the earth's warmer seas. Species are now becoming extinct at 25,000 (Lean 127) to 120,000 times (p 975) the natural rate. Currently there is a species being lost about every 12 minutes and the rate is steadily increasing as remaining areas of high diversity become fractured. The loss

of one plant can cause the loss of as many as 30 kinds of animals and insects which depend upon it, so the whole process has catastrophic potentiality. Three years ago the World Conservation Monitoring Centre reported one in ten forest species are already facing extinction through felling, forest fires and poor forest management. .



New Zealand prides itself as a leader in mechanized agriculture, but at the cost of extensive monoculture that reduces the genetic diversity of the vast majority of the country to monotonous grassland and a small variety of monoclonal agricultural crops with little natural vegetation left to form any type of ecosystem. The impact is seen from satellite view of Mt. Taranaki showing one restricted area of native cover in a relentless sea of pasture (Ayensu 206, 7).

The economic costs of biodiversity loss are becoming apparent in well-studied ecologies such as that if the U.S. “To lose any more of the remaining 3214 rare and endangered plant species in the US could mean throwing away a fortune worth billions of dollars a year. Biotechnology makes it easier to move genes around, so wild relatives could make more of a contribution to the cultivated ones in future. The value of the endangered species is likely to multiply with biotechnology rather than diminish. Over a quarter of current medicines are sourced in plant products. Many others such as antibiotics have origins in bacteria and other organisms. “Worldwide, medicines from wild products are worth some $40 billion a year. Currently researchers estimate only 10% of all species may have been documented and many of these will be lost before we ever find out what potential treasures they contain (Economic Botany, vol 52, p 57).

Apocalypse of Gaia

The great famine which I sense approaching will often turn up
(in various places) then become universal.
It will be so vast and longlasting
that people will grab roots from the trees
and children from the breast. - Nostradamus (Hogue 213)

Wasting the Sheaf of Demeter: The Dwindling Diversity of Food

The health of the world's food resources and harvest productivity is even more dependent on genetic resources. We are utterly dependent on our domesticated food plants and animals for our own survival. Many of these are dwindling in diversity as diverse local types of produce give way to large industrial productions for world markets.

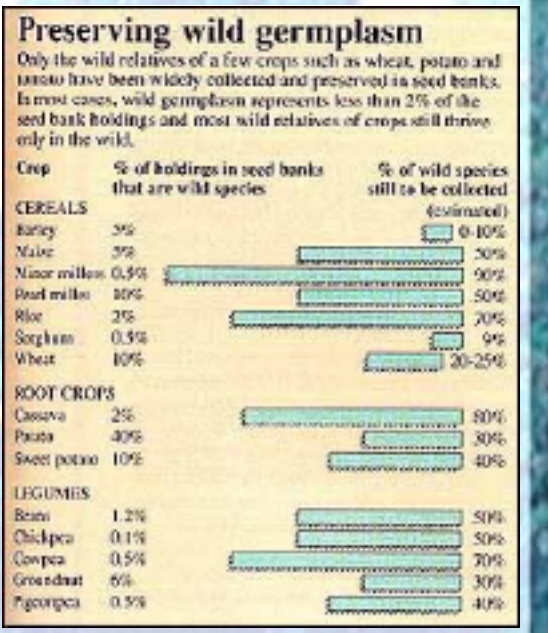
The number of different species being used is dropping rapidly and even more worrying the genetic diversity of even our major staples is being reduced rapidly by major production of low-diversity and even frankly monoclonal genetically-engineered varieties. Just three species - wheat, rice and maize - provide half the world's food; another four - potato, barley, sweet potato and cassava - bring the total to three quarters. Such

overwhelming dependence on a few crops is dangerous; disease can spread rapidly through monocultures - as it did through the Irish potato harvest in the 1840s, causing a fifth of the country's people to die.

The Great Plains: High productivity but near-zero biodiversity (Ayensu 208). Land use devoted to a very small number of low diversity strains.

Crops need to be given new protection every few years, because pests and disease develop ways around their existing defences, requiring one to interbreed them with other strains, often wild ones to introduce new traits. It is believed that the evolutionary race between parasite and host is a principal reason for sexuality in higher organisms. During this century devastating plagues of wheat and maize have been alleviated by cross-breeding back into wild strains some of which have been found in perilous natural habitats. Maize has been particularly vulnerable to such disasters, as inbreeding has given it an almost uniform genetic pattern. Two ancestors of the plant were found in Mexico in the late 1970s. Just a few stalks of them were discovered in a tiny area now threatened with destruction. They can confer resistance to seven of the domestic crop's major diseases, and can turn it into a perennial crop, allowing it to spring up every year like grass, without resewing.

Nevertheless modern industrial agriculture and forestry processes depend ever more recklessly on monoclonal genetically-engineered varieties. Indonesia has a plan to plant 250,000 hectares of forest a year in genetically-engineered monoclonal teak in a single operation. The burning question is where the next generation of such trees will come from once these ones succumb to parasite adaption if the wild areas containing the genetic diversity from which the species come are converted to plantation use. Such short-term thinking could become an evolutionary terminal condition for humanity.



The growing of commercial stocks of low diversity over vast productive areas of the earth's surface has a catastrophic effect on the diversity of the very species on which we depend. The original ecosystemic variety of locally-adapted types is lost as entire regions convert to only a few types. Disease resistance is often only later to be discov-

ered to be missing in all but one or two of the cultivated varieties. Wild varieties in their original habitat are frequently under threat. Yet interbreeding with wild varieties can increase yields and extend the area available for productive agriculture. Some strains of wild wheat, rice, barley, millet and sorghum grow well on salty land; they could be used to create new crops for the vast areas salinated by irrigation.

Most people do not realize how precarious the genetic resource of our food plants is. Four varieties of wheat produce 75 percent of the crop grown on the Canadian prairies. More than half of the prairie is sown with a single variety. Four cultivars of potatoes account for 72 percent of production in the United States. All of the coffee trees in Brazil have been derived from the seedlings of a single plant cultivated in the Amsterdam Botanic Garden in 1709. The entire United States soy-bean stock came from six plants from one place in Asia. The consequences of relying on such a small range of genetic material for our crops can be disastrous (Ayensu et. al. 208, Lean et. al. 127).

Attempts to conserve essential species in seed and germ plasm banks is an essential but extremely limited option which is also prone to devastating failure if a single critical institution is taken out by even a simple power failure. The amount of genetic diversity which can be stored is minimally precarious. Sixty thousand strains of rice, half the world's total, are stored at the International Rice Research Institute in the Philippines, 12,000 types of wheat and maize from 47 countries are kept at the International Maize and Wheat Improvement Center in Mexico. Seeds cannot be stored forever without deteriorating, and are vulnerable to disease. There is considerable danger of attrition through loss of viability through faults in storage.

Plant patenting drives diversity down further, placing legal constraints on free propagation, reducing the entire world market to a few patented varieties, which often have low biodiversity because they are developed from a few highly selected individuals, or even a single parent.

Genetic engineering has even more worrying implications. The first is that new traits are introduced or old ones lost which permanently alter the viability of the species in its own right. Tomatoes which cannot rot cannot naturally nurture their seeds and plants producing alien insecticides may damage the very insects which pollinate them. Some such species contain in addition antibiotic resistance genes which could spread to viruses causing further unnecessary havoc.

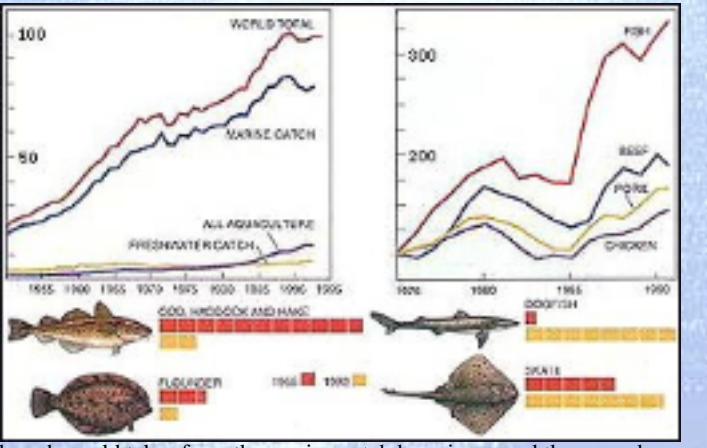
Recently a ‘terminator gene’ has been developed which can render engineered plants infertile on the second seeding making the entire species terminal. Such developments could represent the end of the immortality of the germ line of life over 3000 million years and become the literal death knell of the very species upon which we depend.

Today, within biodiversity all kinds of genetic permutations exist few of which have been explored by gene technologists. Because of the protein-folding problem and the complexity of enzymes genetic technology depends on existing biodiversity for its repertoire of possibilities. Some of these are expressed in overt traits, but others may be hidden in coordinated patterns of gene expression.

Good-bye to Oceanic Diversity

The evidence of the genocide of oceanic diversity is as abundant as the oceans themselves. Populations of fish and shellfish, of corals and mollusks, of lowly ocean worms, are plummeting. Fishing remains the greatest danger to marine biodiversity although toxic tides, coastal development and pollutant runoff are increasing in fre-

quency and dimension as the human population expands. Sudden global warming is bleaching many coral reefs. The oceans - near shore and in the abyssal deep - may be reaching a state of ecological crisis, but, for the public, what is out of sight is out of mind.



Left: Although world takes from the marine catch have increased they may have passed their peak as species are hunted to extinction. Right: Rocketing prices make the process liable to overkill. Fish takes mirror oil trends. Below: As quality fish of high trophic level are reduced to non-commercial levels the take of low trophic level fish has increased (Sci. Am. Nov 95).

The fundamental folly underlying the current decline has been a widespread failure to recognize that fish are wildlife - the only wildlife still hunted on a large scale. Because wild fish regenerate at rates determined by nature, attempts to increase their supply to the marketplace eventually run into limits. That threshold seems to have been passed in all parts of the Atlantic, Mediterranean and Pacific: these regions each show dwindling catches. Worldwide, the extraction of wild fish peaked at 82 million metric tons in 1989. Since then, the long-term growth trend has been replaced by stagnation or decline. In some areas where the catches peaked as long ago as the early 1970s, landings had decreased by more than 50 percent by 1995.

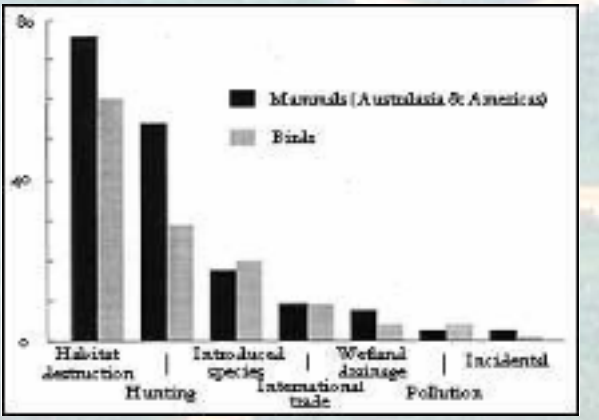
Loggerhead turtle snared by a fishing net. The species faces extinction. Greenpeace protests brought world attention to the problem of drift nets. Bans were put in place. Pilot whale kill by. Faroe Islands fishermen (Porritt 161).

Even more alarming, some of the world's greatest fishing grounds, including the Grand Banks and Georges Bank of eastern North America, are now essentially closed following their collapse - the formerly dominant fauna have been reduced to a tiny fraction of their previous abundance and are considered commercially extinct. European fisheries are now facing a choice of extinction or severely curtailed quotas. Plundering the world's fisheries cannot be sustained.

Preserving Diversity in the Wild

Conservation in the wild is difficult or impossible for domesticated species. Genetic resources often have to be stored in seed banks, germ plasm collections, or by tissue culture. The loss of genetic variety of the wild relatives of crop plants - genetic erosion - may be caused by loss of habitat leading to attrition or extinction of populations and by over-collecting, sometimes by specialists seeking rare exotic species.

The horticultural industry sometimes acts to further conservation by the propagation and distribution of rare species, but in replenishing stocks from the wild sometimes strips rare species, through smuggling of bulbs, rock plants, cacti and succulents, wild birds, lizards and even great apes. Poachers focus their attention on the rarest species - for these fetch the highest prices. This can lead to exploitation of many wild populations by rogue smugglers and traders. Often the plants or captive animals are badly packed and do not survive shipment. The desire for herbal or animal remedies as is common in Chinese medicine can lay waste to rare species from the rhinoceros down.



Habitat destruction is the single most serious factor in animal species loss (Groombridge).

Specialist horticulturists can have an important role to play by successfully cultivating rare species and make them common; thus helping to remove pressure from the wild population and even helping with reintroduction of rare species to the wild.

Cycads have persisted with no real evolutionary change for more than 50 million years but are becoming collectively rare as an entire group. Harvesting of cacti and wild flowers can also be a threat to native species in areas rich in endemic species. Since many set few seed, commercial collecting can lead to danger of extinction.

Pollution can also have devastating effects. World populations of amphibians of all

types are declining mysteriously and dangerously. Estrogenic pollution may be to blame, although a variety of causes including fungal infection have been suggested. Estrogenic pollution by a variety of seemingly inert industrial chemicals, is also causing major sexual abnormalities in fish populations in rivers and may be affecting both human male sperm counts and male to female birth rates.

Left a female tree frog attracts males by tapping a reed (Scientific American Aug 95 63). Right croaking male frog (attenborough 101) There is a world-wide decline in frog populations to the point of international crisis concern. Frogs are susceptible to environmental toxins and pollution because of their permeable skins.

Many other deliberate changes have an impact. Selective removal of plants poisonous to cattle can drive species to extinction but the same toxins may prove to be irreplaceable biochemicals. This has been notable in a variety of cases from curare in arrow poisons to the painkillers in cone snail venom. As biodiversity becomes diminished our future options are slipping through our fingers diminishing by degrees, like tumbling sand.

Recent advances in cancer chemotherapy, based on alkaloids, have revived interest in mass screening of plant tissues for medical activity. Several plant-sourced drugs from Madagascar periwinkle (vincristine) to Pacific yew (taxol) play pivotal roles in cancer prevention. Most such superdrugs probably are to be found in the equatorial regions because this is both where biodiversity is richest and where adaptive responses are most extreme.

However in the tropics, new technologies, often imposed on a massive scale, without due regard for the impacts caused, are damaging the entire genetic base of the ecosystem. There is a tendency to divide wilderness regions into ever smaller islands destroying ecosystemic connectivity and all long range habitats, selectively wiping out certain types of organism. Plantations are most frequently in exotic species and agribusiness methods low in diversity and destructive of ecosystems are also imported. Through such ingress, many native animals, insects, and other plants are lost - with damage to the whole web of vital ecological relationships. Drainage of wetlands for farms often means the loss of native species.

Genetic erosion threatens the genetic diversity of a wide spectrum of species, even relatively common ones, because the original pool of genetic variability that existed in the species has been reduced through the destruction or loss of large parts of their distribution area and or population As forests are felled, marshes are drained, sea coasts are turned into holiday resorts, mountain pastures are trampled and grazed, heathlands are changed into grassland, old rich meadows are ploughed up and planted to crops or re-seeded with standard grass mixtures, cattle and sheep grazing

is intensified, cities expand, industry spreads and roads are widened, so the genetic diversity of all species in every part of the world is diminished.

The widespread damage that the biosphere is sustaining, through physical and chemical damage to the biota, land and waters, particularly in terms of genetic erosion, is far more serious than most people realize, although the cumulative effects leading to an environmental tragedy may take five decades to unfold (Ayensu 208).

Such diversity of genetic resources is already the basis of diverse commercial crops and will be needed more and more as human numbers grow and marginal land is increasingly utilized - and global warming alters the world's climate and rainfall patterns. New crops, and new strains of existing crops, will be essential if the new circumstances are to be addressed. But everywhere, wild plants animals and fungi which could provide them and the diversity of our domestic species, are being allowed to die out.

Constructive and unconstructive human impact: Left Bali. Cultivated regions organically interspersed with palms and forest. Right Chile. Mismanaged logging results in erosion and deforestation (Ayensu et. al. 212, 232).

Patenting, Intellectual Property Rights and Corporate Greed

Now that the enormous value of genetic resources is being realized, countries and companies are fighting over who owns them. The U.S. still remains to ratify the Rio Biodiversity convention because of calculated expediency about intellectual property rights over both modified organisms and natural ones taken from their home habitat and culture.

Some developed and developing countries regard their genetic resources as their property and try to stop them being exported. Some, including the US, claim proprietary rights over all the genetic material they keep from anywhere in the world. Private companies are buying up seed firms; 10 of them control a third of all the cereal crop species listed by the Organization for Economic Cooperation and Development. They may jettison the less profitable species, even though these may have huge genetic potential and are particularly useful on specialized terrain. As seed and chemical companies combine, fears that they will design crops that require their pesticides - and only theirs - to fight off disease have been realized. A particular example is Monsanto which has out-grown and taken over seed companies and now manufactures a variety of agricultural genetically-engineered strains

which must be grown using Monsanto herbicides. The invention of the terminator gene now threatens to make all such genetically-engineered strains non-viable in terms of the continuity of life. The patenting of species and the control of the seed markets by agrochemical companies could become the death knell for the genetic heritage, especially of domesticated species as it marks off the vast productive areas of the planet to genetic oblivion, and a possibly terminal fate for humankind.

Essential Biodiversity: A Guardianship Statement

Biodiversity is not just a benign backdrop for nature holidays, but the very substance and foundation of our survival. We are entirely dependent upon the plants, animals, fungi, and micro-organisms that share the world with us. They alone feed us, and without them we would starve. Yet we frequently act to undermine these very species essential to our welfare. In addition to food, they provide many of the drugs and other medicinal and industrial products on which the quality of our lives increasingly depends. They offer the promise of sustainable economy - productivity that the Earth can support on a continuing basis, so our children and, in turn, their children will survive and be able to live peaceful lives of abundant splendour..

This shipment of Leopards, Jackals and wild cats from the Himalayas was estimated to be worth $14.5 million. Many of our great land animals are under threat of extinction from poaching. One seizure contained cheetah skins representing 10% of the world population (Reuter)

We live in an age driven by the insatiable desire of industrialized nations to go on getting richer, and of free-market economics driven by equally insatiable multinational corporate organizations, competing to exploit the remaining resources of the planet. Though we are now beginning to consider atmospheric changes such as the ozone hole and global warming as significant international problems, we have yet to demonstrate we can hold good to effective action. However at the same time the threats to biodiversity, which are much more long-lasting are not being taken seriously politically. Up to a quarter of the species on Earth may be lost in the course of the next three decades - within the lives of the majority of us alive today, and a majority of biodiversity is likely to have perished by the middle of next century.

Each year we are cutting and burning up to 2 per cent of the world's remaining tropical rainforests; losing an estimated 24,000 million tonnes of topsoil; and adding some 93 million people to a world that is already far too full, judging from the extent of human misery, and starvation, and the depletion of every conceivable resource. Every, point on the Earth's surface, from the frozen wastes of Antarctica to the most remote stretches of the oceans, receives a steady shower

of man-made chemicals. We are clearly "managing" the entire planet now, for better or for worse. Every country needs urgently to develop its own base of information on biodiversity, and strive to understand, to use, and to save it, both for its own purposes and for future generations. For rich nations, this means understanding that we cannot continue to ravage our strictly limited home planet as if its productivity and stability were simply inexhaustible. For poorer nations, the challenge will be even greater, and will not be met without reversing the tragic flow of capital and resources from poor, starving countries to the rich and industrialized. Environmental stewardship and social justice go hand in hand (Peter Raven in Porritt 71).

A precarious living fossil. This stand of Wollemia nobilis known only from fossil records dating back to 250 million years, standing in Wollemi sandstone dating from the same era. Wollemia was common in Pangea from 200 million years and existed worldwide until 65 million years ago and continued in Gondwanaland until 30 million years ago (New Sci. 6 Dec 1997 36).

If the world can attain true sustainability, we who are living now in the most rapid and destructive period of growth that may ever occur, will be seen as having possessed great powers for good and for evil. It is thus essential that we take sufficient step to gain the foresight not to prove to be the destroyers of our own descendents' future. Plants, animals, and fungi, as well as micro-organisms shall continue to become the sources of products that transcend anything we can imagine now and will be used for purposes that have not yet even been conceived. Genetic technology used wisely, will widen the reach of our great-grandchildren, enabling them to put generate organisms that will be productive indefinitely under the conditions in which they are grown. Genetic technology relies on the diversity of existing genes to produce such wonders. These technologies also bring new heightened risks of transfer of material into new places beyond the constraints of natural transfer. It is our responsibility to make sue such uses enhance the sustainability of the biosphere and do not call it short to an abrupt end or a slow death by attrition.

For better or for worse, we find ourselves charged with responsibility for a gigantic living ark on the flood of cultural becoming. What we do next will determine what can be saved. This challenge equals that of having been given a few years, in the middle of the age of the dinosaurs, 100 million years ago, during which we could devise ways to save for future generations some of the organisms that existed for our use, our enjoyment, our pleasure, or simply because we did not want to watch them being lost forever. Several million species, each the product of several thousand million of years of evolution, could be lost forever during our lifetimes. We must find the commitment and ingenuity necessary to reverse the current horrifying trend of destruction as soon as possi-

ble while there is still time.

Each habitat type such as wetlands requires a dedicated sector of the conservation effort. Scotland, the Florida everglades, Okavango Basin, Botswana (Porritt 177).

Endemic Diversity: Hot Spots and Fragile Niches

While in some areas there are only a very limited number of species, other regions, particularly certain tropical forest areas have living diversity in super-abundance. Ecuador has many more plant species than the whole of Europe. Madagascar has five times as many kinds of trees as the whole of temperate North America. The United States contains fewer woody species of plant than a single volcano, Mount Makiliang in the Philippines - and the entire 20 million square kilometers of the North American continent contain fewer bird species than a 2,000-square kilometer national park in Costa Rica (Lean et. al. 133).

A species is ‘endemic’ to a region if it is found only in the specific locality and nowhere else. Some areas have many endemic species. Indonesia has one sixth of the world's bird species, and nearly a quarter of them are endemic. Half of Papua New Guinea's birds, half of the Philippines' mammals, and about 80 per cent of Madagascar's plants are unique to them. Virtually all native New Zealand species are unique. Many islands have unique endemic species because of their evolutionary isolation and are often exceedingly vulnerable because their small populations can easily wiped out by a single disaster.

Tropical rainforests contain the greatest diversity of species. A typical patch, just 10 kilometers square, contains as many as 1,500 species of flowering plant, up to 750 species of tree, 400 different types of bird, 150 butterfly species, 100 kinds of reptile, and 60 species of amphibian. Insects are so abundant that no-one has yet been able to count them, but there may be as many as 42,000 in a single hectare. Madagascar has more than 6,000 unique flowering plants and half the world's species of chameleons are endemic to the island. The Amazonian rainforest helps to make South America the richest continent for wildlife and for biodiversity. It covers an eighth of the world's land surface, but harbours for example around a third of the world's birds. Some local hotspots can contain comparable diversity to whole temperate habitats.

Coral reefs are the rainforests of the oceans. The Great Barrier Reef contains more than 3,000 animal species. The rainforests' nearest rivals on land are areas

with a Mediterranean climate - such as coastal California, the southern part of Western Australia, and the Mediterranean basin itself. These lack the rainforests' diversity of large animals, but have a huge number of endemic plant species.

Areas with high temperatures and rainfall and little seasonal variation - like tropical rainforests and coral reefs - can support many more species than cold, dry places with distinctly different seasons. When areas became isolated from each other, as a result of continental drift, mountain formation, ocean inwelling or drying out of large rainforests into smaller islands, their animal and plant life evolves in different ways. The longer an area is isolated, the more distinct and different its inhabitants are likely to become. The best examples are islands and super-islands, such as Madagascar New Zealand and Australia, with highly distinct fauna and flora, but a similar explanation has been proposed for the high diversity of the Amazon involving insular dry periods during ice ages and re-integration of these island forest sanctuaries during warmer wetter epochs.

Lake Malawi. An 'island' marine ecosystem with recent and rapid evolutionary diversity (New Sci. 2 Aug 97).

As evolutionary paths diverge, different species form, filling the available ecological niches of each habitat. For example, Madagascar's primates (sheltered from the fierce competition that species still faced on the mainland) developed into lemurs, lower primates found nowhere else. Gondwanaland's primates, subjected to greater pressures, evolved into higher forms - including modern monkeys, apes and, ultimately, man. Similarly in New Zealand many of the niches usually filled by mammals have been adopted by flightless birds. Australia's unique array of species evolved similarly in isolation from the rest of the world.

Some islands have never been attached to the continents. Often volcanic, they start out as sterile outcrops of rocks, but later become colonized some even ending as low-lying atolls. Their animal and plant life consists entirely of species which have colonized them from outside. Birds, bats and winged insects and fungi and plants with seeds able to blow in the air, resist the ravages of the sea, or be carried in digestive tracts. Almost 900 species of bird - 10 per cent of the world's total - have a range of only one island.

Any ecosystem or habitat surrounded by a different one is a biospheric island for the species which live there and similar mechanisms of evolution and immigration hold. "Flower-rich areas in Mediterranean climates are such ecological islands, since they have been separated from each other by enormous areas with quite dif-

ferent habitats for millions of years. They support very diverse flora, with a high percentage of endemic species. The same applies to isolated mountainous regions in the tropics, such as the highlands of Ethiopia, Cameroon and the eastern side of the rift valley in central Africa, which between them support a high proportion of the rare species of Africa. Similarly, the rift valley lakes in Africa are isolated from each other and each has evolved it own highly diverse kinds of fish as noted below in the Chichlids.

Lakes Malawi, Victoria and Tanganyika harbour an unparalleled variety of chichlid fishes. Tankanyika supports 250 species, Victoria 500 and Malawi over 1000, 5 times as many as in the whole of Europe. These are now facing invasion of their habitats by introduced exotic species. There have been many discussions over the causes for such diversity. The lake water levels have changed very significantly even over recent history. At least one of the lakes became dry only 12,500 years ago, in an ice-age related event which the species could not be expected to have survived.

A sample of the diversity of chichlid fishes (New Sci. 2 Aug 97).
In Africa's Lake Victoria, more than two-hundred species of fish have disappeared within the past decade. The Boston University ecologist Les Kaufman, who has studied the event in great detail, calls it 'the Hiroshima of the biological apocalypse, the demonstration, the warning that more is on the way' (Leakey 1996).

Biological remains including seeds of pasture species have been dredged from the deepest spot. This places a very short time limit on a very diverse adaptive radiation. Many of the species have very confined habitats on the rocky shoreline and do not cross regions with different character. This may help explain how they could become separated into distinct genetic lines. Their uniquely adapted jaw may also have given them a monopoly over a variety of niches.