Conservation and the Future: Trends and Options toward the Year 2025

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Preface

In August 1995, I was asked by IUCN's Director General to produce a paper on IUCN in the year 2025, as the basis for an in-house discussion of how we might best respond to the rapidly-changing conditions that seem to characterize the modern world. I drew on the work of a wide range of colleagues from within the IUCN Secretariat and more broadly to come up with a draft paper that sought to be as objective as possible, basing projections upon past trends that were supported by available data. I consulted numerous references, but it quickly became apparent that this was an endless task because the literature was so vast. I therefore make no claim of comprehensiveness, and recognize that many useful perspectives -- especially from the South -- have been overlooked.

But I was never under the illusion that any one can actually foresee the future, or that this paper was in any sense a definitive view of the future. As Treumann (1991) points out, "No trend in human-environment interactions is sufficiently long to enable us to make any reliable prediction for anything other than the most simple global processes". And indeed, as the paper seeks to point out, many widely different futures are available, only some of which may be affected by decisions we make today.

I am clear in my own mind that making projections and predictions makes no statement of preference; simply believing that the world faces a finite possibility of all kinds of potential environmental tragedies becoming reality does not in any way suggest that I am *advocating* that any of these happen, nor by projecting implications of new technologies am I advocating that such paths be followed. Prediction is not prophecy. The only intention of this paper is to help people think about how the future might look if present trends continue, what kind of future people prefer, and how decisions that we might take today may affect the decisions that we must take tomorrow.

Nor does the paper claim to be complete; contemplating the future is a totally open-ended game. Not everybody wants to play this game: Albert Einstein said, "I never think of the future. It comes soon enough". Even so, this paper was presented for consideration by the IUCN Membership at the World Conservation Congress, held in Montreal in October 1996, leading to a number of useful comments that have led to this draft. The foundation of this paper was laid by cooperative work done with Kent Redford, Paul Craig, Madhav Gadgil, Neva Goodwin, Harold Glasser, and Debra Rose, in the context of the UNEP/GEF Global Biodiversity Assessment. Sadiq Al Muscati, Ricardo Bayon, John Burke, John Busby, Mike Cockerell, Steve Edwards, Mersie Ejigu, Malinga Fernando, Hans Friederich, Don Gilmour, Meghan Golay, Paddy Gresham, Kevin Grose, Scott Hajost, Mark Halle, Jeremy Harrison, Frits Hesselink, Liz Hopkins, Aban Marker Kabraji, Enrique Lahmann, Claude Martin, Caroline Martinet, David McDowell, David Munro, Gayl Ness, Adrian Phillips, Thomas Price, Mohammad Rafiq, Walt Reid, Nick Robinson, Martha Rojas, Pedro Rosabal, Per Ryden, Dolan da Silva, David Sheppard, Achim Steiner, and Leslie Wijesinghe made substantive contributions. Thanks to William Cowper (1731-1800) for the closing quote.

While working on this paper, I was supported by the Governments of Switzerland (SDC), the Netherlands, and Denmark, whose contributions are gratefully acknowledged. Sue Rallo and Laurence Christen provided the essential secretarial support, and the latter was responsible for the design of the final publication.

Despite this cornucopia of intellectual input, I remain responsible for any misinterpretations, lack of vision, ignored seminal publications, or politically-incorrect statements. And in any case, the future will take care of itself. As Francis Bacon (1561-1626) pointed out, "Men must pursue things which are just in present, and leave the future to the divine Providence".

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30 May 1997

SUMMARY

The rate at which humans are altering the environment, the extent of that alteration, and the consequences of these changes for biological diversity are unprecedented in human history. These pressures on the environment are due to a combination of increasing population, increasing per capita consumption (especially among the wealthier sectors of society), depletion of critical resource systems such as agricultural lands, and inappropriate institutions for managing resources. The pressures are expected to continue to grow, and to be further exacerbated as climate change puts additional stress on the world's productive systems. Clearly, modern society is not in balance with the available resources and the technology used to exploit them, and over-exploitation is beginning to pose substantial threats to the economic and cultural well-being of many communities. By the year 2025, the major problems IUCN is now addressing will be even more challenging. This paper identifies the broad trends and suggests ways that IUCN and other conservation organizations can adapt to the changing conditions. The suggestions are made as a basis for stimulating discussion and debate.

This paper reviews ten major areas -- all inter-related -- where significant changes will affect conservation:

- √ ***Population and resources**. Human populations and inefficient patterns of consumption will continue to grow, putting additional stress on all resources. Conservationists should assess the need to become more involved in efforts to slow rates of resource consumption, especially by the wealthy.*

- √ ***Cultural diversity**. The power of the global market and information technology could lead to the loss of local adaptations to local resource systems. Conservationists will need to promote cultural diversity as the basis for adapting to change, and work with local communities and cultures to build self-reliance.*

√ ***National security***. *The environmental dimensions of national security will become increasingly important, especially involving water and other shared resources; many areas valuable for conserving biodiversity will be adversely affected by insecurity. Conservationists need to build understanding of the linkages between environment and security, identify the interests involved (including the multinational corporations), build capacity to provide technical advice on resource-based conflicts, and work directly with communities.*

√ ***Climate***. *All indications are that climate change will provide a profound challenge to the capacity of societies to adapt to change. Conservationists cannot avoid becoming more actively involved in the issues involved, as they affect all else that we do.*

√ ***Pollution***. *While some improvements are likely, the overall trend is toward greater impacts of pollution on people, the production systems on which they depend, and the "natural" ecosystems of greatest concern to conservationists. "Green" organizations will need to decide on the extent to which they wish to become involved with the "brown" issues.*

√ ***Economics***. *Economics will become accepted as central to all conservation issues. Conservationists will need to apply economic tools -- green accounting, incentives, easements, fees, internalization of costs, subsidies, etc. -- to conservation issues.*

√ ***Institutions***. *The world is in a period of institutional turmoil, as central governments weaken, multi-national corporations grow in size and strength, and NGOs proliferate. The challenge will be how to form effective partnerships with all three sectors. The greatest potential for growth would appear to be the private sector. Conservation organizations will need to be looser and more flexible, essentially working through networking around issues or tasks, serving as repositories of experience on how to deal with problems or opportunities, and mobilizing constituencies to address specific needs. They will need to expand*

their partnerships and consider mergers with institutions working in relevant fields.

√ ***Technology**. Access to technology is what separates the powerful from the weak, and technological advances will exacerbate the differences between rich and poor. But biotechnology -- which will be of great importance for conservation -- offers an opportunity to spread benefits to the community level. This will require the development of appropriate technology, with special efforts devoted to the developing countries.*

√ ***Information and Communications**. Information is power, and modern information technology is leading to revolutionary changes in politics, economics, organizational structures, science, and resource management. Like any powerful technology, information and communications technology (ICT) carries dangers with it. A powerful and effective information-gathering, integration, and dissemination ability will be crucial to conservation, requiring mergers or closer partnerships with information-management institutions.*

√ ***Biological diversity**. The dreary picture of increasing numbers of threatened species painted by SSC's Action Plans will prove to be all too accurate, but new opportunities will increase for involving a broader range of stakeholders in managing species and areas of conservation concern. Conservationists will need to document changes in biodiversity and develop new approaches to deal with these changes, including restoration, community-based management, and improved international cooperation.*

Adaptive management is the key, requiring conservation organizations to: consider a variety of plausible hypotheses about the way the world works; recognize the diversity of local situations where they must work; use a variety of strategies; favour actions that are robust to uncertainties and provide useful information; probe and experiment, and monitor results as a basis for modifying policies; and favour actions that are reversible.

1. INTRODUCTION

As the 20th century draws to a close, it is timely for the conservation movement to reflect on changing environmental, social, economic, and political conditions and how it might adapt to these changes. This paper looks to the year 2025, drawing on the best available science to speculate on the evolution of global environmental trends and issues, evolving pressures on the environment, and obstacles and opportunities for effective conservation action. Based on this assessment of trends, some suggestions will be made on how the evolving context will affect the niche of environmental organizations, what their emerging role might be, what key technical and organizational themes will require their attention, and what they can do to address these issues and best position themselves to be a productive force far into the future. The paper necessarily focuses on the assessment of future trends rather than prescriptions for action, as the implications and responses for each organization are more properly the subject for much broader discussion within the concerned organizations.

The philosophical background for this paper is provided by the **World Conservation Strategy** (IUCN, WWF, and UNEP, 1980) and **Caring for the Earth** (IUCN, WWF, and UNEP, 1991), which have been widely accepted by the conservation movement as the conceptual basis upon which the broadest possible constituency can be mobilized in support of the conservation of nature and natural resources. If the prescriptions in these two documents were followed, this paper might take a very different form; and indeed, a very interesting and useful paper would present a scenario of the year 2025 as if the prescriptions in these two foundation documents had been followed.

Today's world is beset by uncertainties. Five years ago is ancient history, and yesterday scarcely prepares us for today. Suddenly we are faced with new technologies, political juxtapositions, and global disruptions the likes of which our grandparents could hardly imagine. Seeking greater control over their lives, many people have sought to know the future. Today, science has largely assumed the role of fortune-teller. However, with our limited understanding of the biotic and abiotic systems of the earth and our even more limited understanding of human behaviours and cultures, forecasting is at best an

inexact science; as the physicist Neils Bohr once said, "Prediction is very difficult, especially about the future". In fact, it is unclear to what extent our evolving understanding of systems can even enable us to accurately understand why things happened in the past, let alone forecast the future. Furthermore, predictions of the future vary depending on the forecaster's culture, religion, experience and temperament. Remember that the socialist philosopher Lincoln Steffens, after visiting Moscow in 1919, said to Bernard Baruch: "I have seen the future, and it works" -- a conclusion that did not pass the test of time.

Modern fortune tellers -- however closely they may tie their prognostications to science -- can be distributed along a spectrum with "neo-Malthusian pessimists" at one end and "technological optimists" or "cornucopians" at the other. The neo-Malthusians -- often biologists -- tend to think it very likely that human industrial civilization will collapse under the weight of growing consumption of resources and increased environmental pollution, and human life will return to the sort that Thomas Hobbes characterized as "solitary, poor, nasty, brutish and short". According to this position, it is highly unlikely that any group of inventions or investments can permit us to continue living at the level of material affluence taken for granted by the industrial societies today. Modern industrial society has so harmed the natural environment, this position concludes, that ecological and economic turmoil are inevitable, resulting in the collapse of populations and civilizations, perhaps followed by a regrouping at a much lower level of resource use and civilization. The Club of Rome report *The Limits to Growth* (Meadows *et al.*, 1972), for example, predicted that if current patterns of population growth and resource consumption continue, the world economic system would collapse by the mid-21st century. Based on an exhaustive analysis using the latest empirical data and an advanced modelling technique, Duchin and Lange (1994) concluded that only a fundamental change in our lifestyles and a radical change in the way we use technology will prevent continued environmental degradation. Many leading environmentalists, led by Paul Ehrlich, Vandana Shiva, Norman Myers and Lester Brown, fall toward the neo-Malthusian end of the spectrum, either implicitly or explicitly; even when they express guarded optimism about the future, it is difficult to avoid the feeling that they are just trying to avoid being labelled as prophets of doom.

At the other extreme, technological optimists -- often economists -- express conviction that technological advances will rescue us, and that an ever-improving base of material well-being will continue to provide humanity with the option of continuing its experiments in freedom, justice and understanding. While neo-Malthusians use the evidence of growing consumption of non-

renewable resources to logically conclude that such consumption cannot continue, the technological optimists point out that the empirical evidence is quite the contrary. Even though rapid population and economic growth have resulted in enormous increases in the extraction of metals, oil, coal, and other non-renewable resources for which logic dictates that there is only a fixed supply, the cornucopians insist that little evidence indicates that such resources are actually being depleted, as new sources are discovered faster than the old ones are depleted (Simon and Kahn, 1984; Easterbrook, 1995; Bailey, 1995).

For many of these non-renewable resources, prices have been falling or holding steady over the past 20 years, implying to at least some economists that supplies are not declining; indeed, Vincent and Panayotou (1997) conclude that "resource constraints are unlikely to be binding in the foreseeable future". Therefore, they see no need to tamper with consumer behaviour, believing that any shortcomings of today's high-consumption economy can be modified on the supply side. Simon and Kahn (1984), for example, argue that the twenty-first century will bring higher living standards and reduced human impacts on the environment as a result of technological advance and policy innovation.

Easterbrook (1995), providing evidence for the optimists, has argued that the anti-pollution measures taken in the developed world over the past quarter century or so have been a stunning success and that environmental trends in the industrialized world are mostly positive. And in many ways, the quality of the environment has significantly improved over the rather dismal baseline of several decades earlier. For example, over the past seven years, American manufacturers have reduced their releases of toxic chemicals by over 40 percent, and the success of the Montreal Protocols in reducing chemicals which threaten the Earth's protective ozone shield justifies at least some hope that humans can mobilize the political will to change, when the evidence for the necessity of doing so is sufficiently compelling and the measures proposed are economically feasible.

Pessimists might respond that most of these victories have been relatively easy ones against obvious, clear-cut threats to human welfare; that improvements over deplorable levels of environmental degradation hardly counts as "progress", and that such victories are relatively few. Further, the more difficult challenges, they might contend, still lie ahead, especially in addressing the loss of biological diversity, growing maldistribution of wealth, and the very real possibility of climate change.

For virtually any position along the Malthusian-cornucopian spectrum, ample supporting evidence can be mobilized by well-qualified scientists; no position has a monopoly on truth, justice, or reality. Figure 1 shows how different assumptions by a respected futures research institution can produce very different scenarios, of roughly equal probability. Numerous other such scenarios are possible.

An empirical observation is that human societies are self-organizing complex systems involving institutions such as government, property rights, law, and markets. Societies are constantly evolving and adapting to satisfy human wants, providing a framework of rules within which individuals can engage in exchanges of goods and services which are perceived to be mutually advantageous. Market-oriented cornucopians argue that this happens more or less automatically, contending that little evidence exists to indicate that master plans, conservation strategies, or action plans -- despite their popularity -- have much of an influence on these adaptations. They go back to the 18th century economist Adam Smith to quote the power of the "invisible hand" of the market system. But of course even the "invisible hand" needs basic rules to make sure the system works, including ways to ensure that all costs are included in prices paid.

The more extreme free-market optimists might go even farther and blame such strategies for at least part of the problem; they might assert that many environmental problems appear to have been caused or exacerbated by well-meaning attempts to impose order on institutions from above, through one or another kind of plan. The environmental disasters of the centrally-planned economies are perhaps the most dramatic examples, but the generality is widespread; in some sub-Saharan African countries, for example, land degradation is at least partly due to well-meaning government policies which prevent individuals from owning land. The free-market optimists conclude that individuals need incentives to invest in the protection of the natural environment, and the best incentive is the expectation that investments today will bring rewards tomorrow; people need confidence in the future in order to invest in it.

Particularly in the field of conservation, the key issues faced by society are complex and multi-dimensional, with scientific, technical, political, economic, social, and ethical components. Problem-solving and decision-making in the conservation field is difficult because solutions are not clear-cut, they affect different groups in different ways, and the future consequences of alternative actions are uncertain, not least because people continually change their

expectations and perceptions -- and thus their behaviour. Even so, the conservation community has no option but to act, and it should do so on the basis of the best available information, drawing on lessons from history.

Figure 1: TWO SCENARIOS OF THE FUTURE

SCENARIO 1: Governments adopt programmes and policies that foster knowledge-based, ecological, sustainable growth.

This scenario assumes that taxes are shifted from "goods" (income, savings) to "bads" (pollution, consumption); today's most energy-efficient technologies are made available to all countries; energy efficiency grows at 2 percent per year; cyberspace and the "information superhighway" substitutes for a portion of the growth in the transportation sector; and the factors that lead to the stabilization of population (higher education, improved status of women, old-age security) are broadly adopted.

Given these assumptions, the Global Futures Foundation estimates the world's 5.5 billion inhabitants would grow to about 8 billion by 2050, then decline towards 6 billion by 2100, and in 2050 would share a standard of living three times the average today, while using 30 percent less energy and emitting 56 percent less carbon than today.

SCENARIO 2: Industrial-style growth continues, along with the continued subsidizing of pollution and consumption, and penalizing savings and investment.

Elements of this scenario include maintaining the current bias of the economy toward waste and inefficiency; taxes continue to penalize income, savings, and investment; energy and material efficiencies are no greater than today's; every emergent economy follows the development path of today's industrial world and adopts resource-intensive industrial technologies; educational averages remain where they are today; and no actions are taken to accelerate a decline in fertility rates.

These assumptions led the Global Futures Foundation to project that by 2050 fossil fuel consumption would be four times as great as today, carbon emissions would increase 295 percent, the global population would be 16.8 billion and still growing by the end of the 21st century, and depletion-financed waste would be 130 percent higher than today's, leading to income of 50 percent below the US poverty line in 1990. They did not speculate on the social turmoil that might accompany such a scenario

Figure 2: WILD CARDS IN THE FUTURES GAME

Even geniuses have trouble predicting the future. The renowned British physicist Lord Kelvin confidently asserted that "X-rays will prove to be a hoax" and "Radio has no future"; Albert Einstein concluded that "there is not the slightest indication that energy will ever be obtainable from the atom"; and it was apparent to Thomas Edison in 1895 that " the possibilities of the aeroplane have been exhausted" (Milsted, 1995).

Projections are built on assumptions, and these tend to expect relatively smooth changes from the past. But recent work in the theory of chaos and complexity has shown that even small changes can lead to profound and unpredictable outcomes. Big changes can be even worse, and the projections on the following pages assume that none of the following will occur, even though each has a finite possibility of happening -- and profoundly changing the trajectory of the projections:

- √ A collapse of the global monetary system, perhaps as the US$800 billion of bad debts held by Japanese banks come due.
- √ A major war involving the use of nuclear weapons, for example in Kashmir or the Middle East.
- √ A global disease epidemic, perhaps initiated by biological warfare technology.
- √ The virtual collapse of one of the major grain crops (wheat, rice, maize) due to disease or pestilence.
- √ Contact with intelligent extra-terrestrial life, either threatening or benign.
- √ A rapid acceleration of global warming, or cooling, perhaps precipitated by a massive volcanic eruption, an asteroid striking the Earth, or a sudden change in an oceanic current such as the Gulf Stream.
- √ A fundamentalist religious movement effectively opposing the global economy and advocating local autonomy and the virtues of an austere lifestyle.

On the more optimistic side, unforeseen technological breakthroughs could enable society to meet its needs on less land and with essentially zero pollution, leaving more land available for conservation uses. The conservation challenge then would be almost entirely how to manage human behaviour, a joker in the deck.

2. LESSONS FROM THE PAST: TRENDS AND PROJECTIONS

"Time present and time past
are both perhaps present in time future,
and time future contained in time past".

(T.S. Eliot)

This section will examine current trends in ten areas of critical interest to conservation, project these trends into the future, and suggest how conservation organizations might respond to these trends. These ten areas are treated separately, but it is clear that all are inter-connected, and that complex synergies are to be expected, leading to many surprises in the future.

2.1. Changes in Population, Consumption, and Resources

Optimistic as well as pessimistic forecasters of the world's future recognize increasing demand by expanding human populations as a source of immense stress on resources. The world population in 1990 was about 5.29 billion, 78 percent occurring in the developing countries (effectively all countries excluding Europe, North America, Japan, Singapore, Australia and New Zealand). Significant increases are anticipated in total world population in the coming decades. Lutz *et al.* (1993) considered three components of population change -- fertility, mortality and migration -- and using various estimates of the range that these three components could realistically take, developed nine

population scenarios. Although these resulted in a wide range of possible outcomes, three conclusions were consistent:

- √ World population will continue to grow and by 2030 will have increased by at least 50 percent, and may even have doubled in size. The "central scenario" suggests an increase of 80 percent with a population of 9.5 billion (Figure 3).

- √ Developing countries will account for a greater share of the world population that will have increased to 86 percent by 2030. Under all scenarios Africa's share of the population will increase most rapidly (the central scenario estimates Africa's population will increase from 12 percent of world population in 1990 to 19 percent in 2030 and 26 percent in 2100).

- √ All populations will become older. The more rapidly fertility declines, the faster populations will age. This "greying" of the population will have profound social, economic, and political implications. One important implication of lower population growth rates (or even population declines) combined with increasing life spans is that the percentage of the economically-productive population will decline while the demands of pensioners will increase. A recent study by OECD forecast particularly significant problems for France, Germany, Italy, and Japan, where state pension obligations would peak at about 15 percent of gross domestic product (GDP) during the first half of the next century, compared with current levels of between 5 and 10 percent; even this falls far short of the contributions made to the pension system by taxpayers (Bruce, 1995).

If the demographers' consensus holds true, we are about halfway towards a level population of between 8 and 12 billion people, barring major catastrophes such as global warfare, massive volcanic eruptions, new virulent diseases of

people or crops, etc. It is perhaps timely at this point to consider the likelihood of some of these potential limiting factors. For example, despite all the efforts of modern medical science, humanity is still threatened by the resurgence of familiar diseases such as malaria, tuberculosis, cholera, bubonic plague, yellow fever, syphilis, and AIDS; as well as the newly-emerging viruses and bacterial infections that scientists are only just beginning to identify, including Legionnaire's disease, the rodent-borne hantaviruses, toxic shock syndrome, lassa fever, Marburg virus, and Ebola virus (Garrett, 1994). And the growing urbanization of most societies has created dense population centres where poverty, poor sanitation, and over-extended health care systems combine to create ideal conditions for epidemics. At the same time, cheap and accessible air travel has helped to create a global village in which microbes can migrate from one remote region to another within just a few hours. Because the impact of disease over the past several decades has been relatively minor, many people act as though the threat of disease to civilization has essentially been brought under control. However, this appears to be a significant misreading of history, which demonstrates that disease organisms have a tremendous capacity to react to dense human populations by developing new and occasionally highly deadly strains (Burnet and White, 1972; Dubos, 1979; May, 1958). Many of these outbreaks of disease seem to be closely related to significant human modification of the environment (May, 1972). Thus at least some observers believe that disease will have an increasingly significant impact in the future, possibly influencing the direction of human civilization (Miller, 1989; Nikiforuk, 1992).

How many people can the Earth support? Determining optimum human population is no simple matter, as it depends very much on what kind of life people will expect to lead. The minimum viable population size is one that is just sufficiently large to ensure against extinction, while the maximum number that could be supported by the planet's life-support systems could be in the multiple billions, especially if people ate sufficiently low on the food chain to become much smaller in body size. Whittaker and Likens (1975) have

estimated that an "agricultural world", in which most human beings are peasants, should be able to support 5 to 7 billion people, probably more if the large agricultural population were supported by industry-promoting agricultural activity. In contrast, a reasonable estimate for an industrialized world society at the present North American material standard of living would be one billion. At the somewhat more frugal European standard of living, two to three billion would be possible. Some scientists contend that the highest quality of life would come with a human population of around 1.5 billion, about the same number of people as existed at the turn of the 20th century (Rapalus, 1994). Cohen (1995) concluded that the capacity of our planet to support people is determined both by natural constraints and by human choices concerning economics, environment, values, politics, and demography, so human carrying capacity is dynamic and uncertain.

However, it seems apparent that economic growth brings inevitable expansion in human demands upon the resources of the planet. For example, OECD -- an organization toward the cornucopian end of the spectrum -- has forecast that by 2010, China, India, and Indonesia could support approximately 700 million people who have an average income equivalent to that of today's Spain, and that by 2025, 2-3 billion people in the developing countries will have reached middle-class affluence. A group of Latin American political leaders has charted a path for their region to achieve such growth, and estimated the impacts that could be expected on the environment (Comisión de desarrollo y medio ambiente de America Latina y el Caribe, 1990).

Because per capita demand for biotic resources has increased, the population-fuelled increase in direct exploitation of resources has been exponential rather than linear. The human species now appropriates some 40 percent of the net primary productivity of terrestrial systems (Vitousek *et al.,* 1986), though of course much of this is consumed also by domestic plants and animals, and serves to support the wide variety of micro-organisms that find our species a congenial habitat. Much of this productivity is channelled to people via

agriculture. Between 1950 and 1984, per capita grain production increased by 40 percent, and between 1950 and 1990, per capita supply of beef and mutton increased by 26 percent. In addition, world fish catches underwent a 4.6-fold increase between 1950 and 1989, doubling per capita production of seafood. World consumption of wood also increased 2.5-fold between 1950 and 1991, per capita consumption increasing by a third during this period (Durning, 1994). As with food consumption, most of the growth in total and per capita wood consumption has occurred in the developing world, primarily because these regions were starting from a lower baseline of consumption.

Figure 3: Total population size in 12 world regions under the central scenario (in millions) (Lutz, 1993; UN, 1994 estimate)

	1990	2010	2030	2050
Northern Africa	140	215	332	541
Sub-Saharan Africa	502	854	1,499	1,800
North America	277	332	376	389
Central America and the Caribbean	147	207	289	300
South America	294	397	516	539
W. & C. Asia	197	312	442	553
South Asia	1,191	1817	2,428	2,673
China + Hong Kong	1,159	1394	1,722	1,612
Southeast Asia	518	607	937	851
Japan, Australia, and New Zealand	144	152	160	139
Eastern Europe	345	304	380	289
Western Europe	377	425	416	389
Developing regions	4,149	5,819	8,167	8,624
Industrialized regions	1,142	1,213	1,333	1,208
World total	5,285	7,032	9,500	9,833

Our planet will need to support more people in the future, and most of them will want to consume more resources.

It is often said that poverty is the worst polluter, but an even stronger case can be made that consumption is an even worse polluter. Kennedy (1993) concludes that the average American baby represents twice the environmental damage of a Swedish child, three times that of an Italian, 13 times that of a Brazilian, 35 times that of an Indian, and 280 times that of a Haitian because its level of consumption throughout its life will be so much greater. Thus even though the population of the developed country is relatively low and stable, its impact on resources is far greater than that of the developing world (Shiva, *et al.*, 1991).

Some indicators suggest that ecosystem and resource limits are already being reached. World fish harvests peaked at 100 million tons in 1989 (for comparison, whales annually consume at least 300 million tons of marine organisms, according to Japanese scientists), and by 1993 had declined 7

percent from 1989 levels. Growth in grain production has slowed since 1984, with per capita output falling 11 percent by 1993. World economic growth as measured by GNP has slowed from over 3 percent annually in the decade 1950-1960 to just over 1 percent in the decade 1980-1990 and less than 1 percent from 1990 to 1993. The Worldwatch Institute, extrapolating from historical data, forecasts that "If current trends in resource use continue and if world population grows as projected, by 2010 per capita availability of rangeland will drop by 22 percent and the fish catch by 10 percent. The per capita area of irrigated land, which now yields about a third of the global food harvest, will drop by 12 percent. And cropland area and forest land per person will shrink by 21 and 30 percent, respectively" (Postel, 1994).

Some countries are likely to greatly expand their impact on world food supplies. For example, Brown (1995) estimates that by 2030, China will need to import between 210 and 370 million tons of grain annually, out of a total world production of 2.15 billion tons. The entire world produces only 200 million tons of grain for export each year, but other regions also have hungry mouths that need to be fed; some estimates are that Africa will need to import 215 million tons of grain annually by the year 2030. China, with 1.2 billion people, has only half as much arable land as the US.

The potential for further expansion of cropland area is thought to be small. Current figures show that roughly one-third of global land area is used in food production, 1.5 billion ha of this being used as arable land (Kendall and Pimental, 1994; Döös, 1994). This current arable land area will decline as expanding global populations compete with agriculturalists for land for urban and industrial purposes and land degradation takes its toll. While the further potential for conversion of land to cropland is on the order of 1.5-1.7 billion ha, the areas with the best potential for cropland are already being used in this way; to realize any further expansion of arable land will involve the conversion of marginal areas such as tropical forests on infertile soils, steep hillsides and semi-arid regions which support relatively fragile resources -- and a great deal of the world's biodiversity. These areas are today inherently

unsuitable for crop production due to various physical and chemical soil constraints or unreliable rainfall, but biotechnology may make these areas suddenly more attractive for agriculture (see section 2.8).

While feeding the growing population will certainly be an increasing challenge in the coming decades, some parts of the world -- notably western Europe -- are removing land from agriculture and taking steps to reduce production. This is due at least partly to the very high costs of producing food through energy- and technology-intensive agriculture, which raises the possibility that the world may be capable of producing sufficient food to support a much greater population in the year 2025, but that the real constraint will be the price of food; the wealthy countries will be able to produce surpluses, while the poor countries will be unable to purchase those surpluses to feed their own populations. Juma, Mugabe and Kameri-Mbote (1995), on the other hand, argue that biotechnology in Africa can be a significant source of additional productivity on existing land, thereby reducing the necessity to over-exploit marginal land or import food from Europe.

Rural populations have grown along with urban populations, though at slower rates. For the world as a whole, that is projected to remain the case through 2015. Between 2015 and 2025, however, the medium variant 1994 projection has the world's total rural population declining from 3.33 to 3.23 billion. As might be expected, these projections for the world as a whole mask significant differences between the more and less developed regions. Rural populations in the less developed regions are projected to follow roughly the world pattern, peaking at 3.09 billion in 2015, then declining over the subsequent 10 years to 3.03 billion. The industrialized countries, on the other hand, reached their peak rural population of 366 million in 1950 and have shown a decline since then, to 301 million in 1990, projected to decline further to 198 million by 2025. This represents a 40 percent decline in 75 years.

Among the more developed countries, Japan's rural population has been declining from its 1950 level of 42 million, to 28 million in 1990, and is projected to be no more than 18 million in 2025. This is roughly equal to the more or less stable rural population that obtained throughout much of the Tokugawa period. The rural population of the Russian Federation is projected to decline from the 1950 level of 57 million to 26 million in 2010, and further to 20 million in 2025. Europe is expected to show the same trend, cutting its total rural population more than in half, from 266 in 1950 to 121 million in 2025. Only North America among the more developed regions is expected to show absolute increases in the rural population, from 60 million in 1950 to 69 million in 2010 (averaging less than 0.3 percent growth per year), from which point it is expected to decline. Even in North America, however, many rural counties are already losing population, and some observers expect this process to continue. On the other hand, improved communications technology and growing urban problems may encourage a return to more amiable rural settings.

The decline in rural populations may mean that wilderness in at least some parts of the world is actually likely to increase, not decrease. In the USA, for example, the largest rural counties tend to be those which have the largest relative population losses (Popper and Popper, 1991). Conservation uses will often be the most plausible alternatives on the land that the extractive industries will abandon, and declining rural populations will provide new opportunities for biodiversity conservation -- provided that rural population decline is not accompanied by increasingly mechanized extensive resource extraction and agricultural production to support the growing urban populations (Shiva, 1991).

So in at least some parts of the world, land under agriculture may be reduced as populations shift to cities. Thus the world is likely to see some areas devoted to labour-intensive agriculture, other areas devoted to capital-intensive agriculture (including increased mechanization), and yet other areas used for marginal agriculture at low levels of productivity. Despite growing population,

the trends indicate that some possibilities will exist for expanding the area available for conservation purposes, but only if development provides real alternatives to agriculture on marginal lands (Sankaram, 1993).

The increasing percentage of the world population will be urbanized marks a fundamental change in the relationship between people and land. Urban-dwellers tend to have a more consumptive lifestyle than their rural cousins, and the feedback loop between urban-dwellers and their environmental support systems tend to be much larger than those found in rural areas. Urban people thus seek additional ways of maintaining at least some contact with nature, for example through importing increasing numbers of plants for domestic gardens. At least some of these species may become established, and some cities have much more species diversity than the surrounding countryside; London, for example, supports more species of plants than all of the rest of England combined.

An optimist might conclude that history indicates that people living in cities will find increasingly creative ways to maintain contact with the natural world, or at least some form of it. A pessimist might look at expanding cities in developing countries and question whether the burden of pollution, inadequate waste management, poor living conditions in slums, and less domestic production of food lead to more inputs, more debt, more extraction and export of natural resources leading to more poverty (Ezcurra and Mazari-Hiriarit, 1996).

Many experts believe that water scarcity rather than shortage of land will be the main constraint on agricultural development in the coming decades. Global demand for water has historically increased at a rate of about 2.3 percent a year, doubling every 21 years, but supply can no longer keep up with this rate of growth. The Earth's water supply is being pressured by the demands of a growing human population for water for agriculture, industry, and domestic use; contamination of good-quality water through pollution originating from

domestic waste, industry, and agricultural chemicals; and the increasing costs of developing new water sources, since most of the readily-tapped sources have already been developed. Singapore, for example, is expected to run out of water by the year 2001 if it increases its water usage at the current rate of 6 percent a year. About half of Singapore's total land area of 641 sq km is already devoted to water catchment, but no more area is available for additional reservoirs. Singapore is now importing water from Malaysia, but even in such a high-rainfall area, demands for water are increasing at an alarming rate and the government is concerned about the sustainability of current approaches to water supply. Options being considered include increasing water tariffs to reduce consumption, desalinization to convert sea water to fresh water, and developing water supplies in Indonesia's nearby provinces for export to Singapore.

Another disturbing trend has been the rising concentration of income worldwide. From 1960 to 1989, the share of world income going to the poorest 20 percent of its population declined from 2.3 percent to 1.4 percent, while the share of income going to the richest 20 percent increased from 70.2 percent to 82.7 percent (UNDP, 1992). In other words, while per capita consumption is actually declining in many parts of the developing world, 83 percent of world income is concentrated in the hands of "biosphere people" -- those who are able to mobilize resources from the entire world and who are relatively immune to local over-exploitation (Dasmann, 1977), and whose disproportionate share of disposable income allows them access to increasing quantities of consumer goods. The private sector is also concentrating wealth; the 50 largest corporations control 25% of the world's economic output but employ only one-twentieth of one percent of the world's population; 1991 sales of the 10 largest corporations exceeded the combined GNP of the 100 smallest countries, and the top 300 transnationals owned some 25% of the world's productive assets (Korten, 1995). Whether this trend will, or can, continue will be a critical issue in the coming decades (Shiva *et al.*, 1991; de Botero y Tokatlian, 1983).

The trends outlined above indicate that modest incremental change can eventually yield cumulative impacts that are overwhelming, especially because change often happens exponentially. Neo-Malthusians can observe that seemingly small increases in population and consumption can produce near-term disasters, from mass starvation to global climate change. But cornucopians can respond that the opposite is also true, in that relatively small annual improvements in energy and resource efficiency, modest reductions in fertility, and slight but consistent reductions in pollution and waste, could yield substantial benefits in a few generations. And more people, they may contend, means more brains for innovation and creativity.

POPULATION, CONSUMPTION AND RESOURCES: PREDICTIONS

The human population of the world will continue to expand, and economic growth will lead to expanding consumption, which will put increasing stress on resources. However, the changes in population and consumption will be highly variable from region to region, with profound social, economic, political and security implications. These trends will be exacerbated by the general pattern that population growth is greatest in those regions least able to support more people. The picture may be as follows:

√ **Africa** presents the most serious problems of population growth. With economic stagnation over most of the continent, and reduced mortality but little or no reductions in fertility, it may grow from its current 600 million to 1.4 to 1.6 billion in 2025, and still be expanding at annual rates above 2 percent. Alone among the world's major regions, the population of Africa has grown much more rapidly than its cereal output, bringing a decline in per capita output.

√ **East Asia**, with a population of 1.3 billion, vibrant economic development, and where fertility has already fallen to replacement level, may reach a more-or-less constant population of 1.6 to 1.8 billion and become the world's dominant economic grouping,

consuming an increasing share of the world's resources (Brown, 1995).

- √ **South Asia**, with a population of 1.2 billion, still has moderately high fertility rates and relatively modest economic growth. It may reach 2-2.4 billion by 2025, and still be growing by more than 1 percent per year. Serious population-resource conflicts can be expected (Shiva et al., 1991).
- √ **Southeast Asia**, with a population of just under half a billion, booming economies, and substantial reductions in fertility, will grow to 640-780 million, with growth rates possibly below 1 percent per year. Growing industries will concentrate population in urban centres, leaving possibilities for biodiversity in the rural areas.
- √ **Latin America**, with about 450 million people and accelerating economic development, is the most urbanized of the developing regions; rural populations have been declining since 1985. Brazil began to experience negative growth rates in its rural population as early as 1970-75; from the peak of 42 million, its rural population is expected to decline to 25 million by 2025. With continued improvements in fertility reduction, Latin America's population may reach 625 million by the year 2025, but slower reductions in fertility may enable the population to reach 780 million.
- √ The **OECD countries** are likely to continue their fertility declines and many of the countries will have difficulty maintaining their current populations, instead facing significant problems of an ageing work force, increasing numbers of pensioners, and a growing tide of immigrants. Population pressure on biodiversity will be relatively low, but pollution will be a serious threat. Their percentage consumption of the world's resources will decline as the developing countries expand their consumption of resources.

Arrow *et al.* (1995) conclude that the carrying capacity of our planet may well have significant limits, while recognizing that improvements in the management of resource systems, accompanied by resource-conserving structural changes in the environment, could enable economic and population

growth to continue despite the finiteness of the environmental resource base (at least for some period of time). Others believe that an optimal human population level would be around two billion, roughly 40 percent of today's population; they do not prescribe how to achieve this reduction, which would surely involve tumultuous social and political change. However, even the optimists agree that the increasing scarcities of the resource base as the human population continues growing need to be effectively reflected within the economic system (see section 2.6).

2.2. Changes in Cultural Diversity

The importance of cultural diversity was recognized by the conservation community in the **World Conservation Strategy** and **Caring for the Earth.** Clearly, local knowledge about the environment is very important, but how realistic is it to continue worrying about cultural diversity when the world increasingly is becoming a global village, all tuned to the same news programmes, television programmes ("Baywatch", a fluffy sun-and-sex Malibu melodrama, has just been launched in Russia, with an audience of 76 million), popular music, and movies, eating the same food, wearing the same clothes, using the same consumer products, and being cured by the same drugs?

The most pervasive changes to modern culture are being brought about by the spread of knowledge, which in turn feeds on new information technologies (see sections 2.8 and 2.9). The global market and expanding communications technology mean that the world is in very real danger of having reality replaced by virtual reality, at least for urban-dwellers. If we live in a world where people do not need to travel to communicate, the depth of our understanding of different realities and different cultures inevitably will diminish, as video replaces experience and stimulation replaces contemplation.

A global culture means a single language -- undoubtedly some form of English -- and a loss of the cultural diversity that enables people to adapt to their local

conditions. Optimists will see this as an opportunity for increased welfare for all, accepting that the dominant desire of people is consumption of growing amounts of consumer products. Pessimists will be alarmed by such trends, contending that the dominance of the rich will only increase at the cost of local self-reliance.

In seeking to assess changes in cultural diversity, it is worth keeping in mind that cultural and biological diversity are closely related. Just over 83 percent of the world's languages (5,635 out of 6,760) are endemic to a single country (Grimes, 1992). Of the 25 countries with the highest number of endemic higher vertebrate species (mammals, reptiles, birds, and amphibians), 16 are also among the top 25 in endemic languages -- a concurrence of 64 percent. The factors which lead to high levels of species endemism -- geographic isolation, landscape diversity, complex geological history -- also lead to linguistic endemism, so efforts to conserve biological and cultural diversity can be highly complementary.

Conserving cultural diversity is not simply an exercise to maintain a living museum of anthropology. As Diamond (1994) points out, while scientific research is greatly increasing, in other respects our knowledge is shrinking. The knowledge humans have built up over millions of years about their local environment is so extensive that not even professional biologists can hope to capture more than a small fraction of it, but the languages in which this knowledge is recorded are disappearing very quickly. In the countries with the greatest linguistic diversity, such as Indonesia and Papua New Guinea, the governments are consciously trying to reduce the number of languages being used. Diamond concludes: "While the reasoning behind such decisions is, of course, understandable, the outcome is that all but about 200 of the modern world's 6,000 languages are likely to be extinct or moribund by the end of the next century. As humanity's linguistic heritage disintegrates, much of our traditional, mostly unrecorded, knowledge base vanishes with it. The analogy that occurs to me is the final destruction, in A.D. 391, of the largest library of the ancient world, at Alexandria. That library housed all the literature of

Greece, plus much literature of other cultures. As a result of that library's burning, later generations lost all but the Iliad and Odyssey among Greek epics, most of the poetry of Pindar and Sappho, and dozens of plays by Aeschylus and Euripides -- to mention just a few examples".

Over the past several generations, the highly diverse and often localized adaptations of local human cultures to local environmental conditions have been profoundly disrupted in most places by a world culture increasingly characterized by very high levels of material consumption, at least for a privileged minority. Economic growth based on the use of fossil fuels as an energy source, greatly expanded international trade, and improved public health measures have spurred such a rapid expansion of human numbers and consumption of resources that new approaches to resource exploitation have been required. These approaches, often involving powerful machinery, sophisticated technology, and arcane economic instruments, have overwhelmed the conservation measures that local communities had developed from their long experience of surviving in an uncertain world (Gadgil, 1987; Shiva, 1988).

This appears to be an inevitable side-effect of the world becoming a single global trading system, using new technologies and new approaches to exploit resources. This means that products from local ecosystems are being harvested to feed the demands of distant, unpredictable markets rather than responding to local conditions of supply and demand. Often using heavy subsidies in the form of agricultural chemicals, fossil fuel, pesticides, and so forth, governments have replaced traditional systems of resource management with new systems imposed or adapted from other parts of the world. These new systems are able to yield considerable income, but the highest profits are earned when the full social and economic costs of resource depletion are not paid (in the economic term, "externalized"). For example, logging is far more profitable when the loggers do not need to compensate traditional owners for their loss of goods and services from the forest. Instead of being included in

the prices paid for the timber, these environmental costs are transferred to society as a whole, to be paid either now or in the future. Further, royalties for local knowledge about plant varieties are not paid; UNDP (1994) estimates that the developing world would gain about US$5.4 billion per year if multinational food, seed, and pharmaceutical firms paid such royalties.

This analysis suggests that we should not be surprised that forests, grasslands, coral reefs, and the species they support have been grossly overexploited, forcing government officials into pitched battles with "poachers", conflicts with indigenous people, and draconian policy measures such as exclusion of people from resources upon which their lives depend. And since the cultural survival of many rural people depends directly on how they manage natural resources, the "nationalization" of resources has had a profound impact on their cultures.

At least half of the world's cultures are in danger of being lost in the next few decades. Such loss will also involve losing local knowledge about resource management.

As a result of the global market, both biological diversity and cultural diversity are being depleted. While the loss of biodiversity is now well recognized, cultural diversity is also under serious threat. Brazil alone has lost 87 tribes in the first half of this century, and one-third of North American languages and two-thirds of Australian languages have disappeared since 1800 (Durning, 1992). In sum, over half of the world's 6,700 languages are now moribund, spoken only by people who are middle-aged or older (Harmon, 1995). This depletion poses a significant threat to humanity, which can exist in the long term only through a sustainable and interwoven relationship between nature and culture. Cultural variability can provide flexibility for adapting to the inevitable changes of the 21st century.

The system of trade which has enabled the entire globe to be exploited, primarily for the benefit of urban populations, has led to great prosperity for those who have been able to benefit from the expanded productivity, but it has often led to devastation of local ecosystems and local cultures. And what happens to the local people who remain dependent on the now-depleted living resources, and indeed had developed ways of using these resources sustainably, without depleting them?

The World Commission on Environment and Development provided an answer: Growing interaction with the larger world is increasing the vulnerability of these isolated groups, since they are often left out of the processes of economic development. Social discrimination, cultural barriers, and the exclusion of indigenous people from national political processes makes them vulnerable and subject to exploitation. Many groups become dispossessed and marginalized, and their traditional practices disappear. They become the victims of what could with justice be described as cultural extinction (WCED, 1987).

This is not a trivial problem. "It is a terrible irony that as formal development reaches more deeply into rain forests, deserts, and other isolated environments," says the WCED (1987), "it tends to destroy the only cultures

that have proved able to thrive in these environments." And destroying these cultures will reduce the capacity of our species to adapt to change.

The urban centres which characterize modern industrial civilization have long viewed nature and culture as distinctly different, even opposing, concepts. Today's dominant symbol is money -- a very distant and abstract way to characterize resources -- and it is replacing natural symbols of proven worth to so-called "primitive" peoples. Maybury-Lewis (1992) pointed out that as the end of the century draws near, the modern world is marked by unprecedented degrees of confusion, insecurity, and yearning for change. Industrial society -- today characterized by high unemployment, growing budget deficits, ageing work forces, and social strife -- is losing self-confidence in the face of the future. Under such conditions, the value of tribal wisdom can be fully appreciated, bringing an opportunity to consider new models for living in balance with resources. A return to tribal or "primitive" lifestyles is not a realistic answer for the industrialized world or a feasible option for most of the world's 5.5 billion people, Maybury-Lewis points out, or for the projected doubling of the world population in the next century. Rather, new and sustainable systems of resource use can incorporate the traditional knowledge and wisdom of indigenous peoples to develop new and more sustainable relationships between people and resources.

Cultural diversity also serves as a form of insurance, helping to expand the capacity of our species to adapt to the kinds of changes discussed in this paper.

Partly in response to demands for greater local autonomy, numerous community-based groups are springing up in all parts of the world, in a kind of re-assertion of traditional self-reliance as governments find it more difficult to maintain their previous levels of intervention. Community-based groups include formal and informal local cooperatives, village councils, resident associations and other such arrangements established to support and promote the interests of their individual members or of the community as a whole. While some governments, such as Bolivia, are actively supporting such efforts,

it is more likely that non-governmental groups and grass-roots organizations will increasingly take the lead. In Zimbabwe, for example, private land conservancies are often larger, and better managed, than some state-owned protected areas.

NGOs often support such community-based groups and can provide a vital linkage between them and the formal government sector. This is often a difficult procedure, especially when governments are suspicious of the political motives of community organizations and those who support them. But this "privatization" of resource management based on cultural diversity will certainly increase, and be of great interest to conservationists in the coming decades.

CULTURAL DIVERSITY: PREDICTIONS

Degradation of habitats will convince communities to become more possessive of their environmental assets, and they will start taking better care of them. Resource management will become a function of negotiated settlements, involving trade-offs, environmental cost-benefit analyses, valuation exercises, and incentives. Scarcity and associated conflict resolution options will emerge as driving forces in development and conservation. Human rights, good governance, and equity considerations will begin to feature more as distributive justice no longer offers win-win options.

By the year 2025, at least 15-25 percent of the world's current 6,700 languages will be lost. At the same time, many other ethnic groups will be reasserting their identity through a variety of means ranging from education to insurrection.

As reproductive rates continue to decline, the role of women will continue to change, and gender-based determination of roles will undergo profound changes in many parts of the world.

Some ethnic groups will fight against joining the "global village", resisting -- sometimes violently -- the dominant system of consumer values. Such groups will provide the basis for a post-consumer society, but in the meantime will be

considered "poverty-stricken" and therefore legitimate targets for outside assistance to force them to "develop" so they can become part of the global marketplace.

More people will come to understand the point made by development philosopher Denis Goulet: "It is discomforting for a sophisticated technical expert from a rich country to learn that men who live on the margin of subsistence and daily flirt with death and insecurity are sometimes capable of greater happiness, wisdom, and human communion than he is, notwithstanding his knowledge, wealth, and technical superiority".

Increases in the knowledge of the biological basis of human behaviour will be coupled with increasing knowledge of the effects of culture, social structure, and the environment on both normal and pathological behaviour of people. This increasing understanding of human behaviour may provide a powerful tool for both conservationists and exploiters. Religious groups will strongly resist the new mechanistic understanding of humanity.

2.3. Changes in National Security

National security is already seen in increasingly environmental terms (Myers, 1993). The project on Environmental Change and Acute Conflict, a research effort sponsored by the American Academy of Arts and Sciences and the University of Toronto, has found considerable evidence that scarcities of renewable resources are already contributing to dislocations and violent conflicts in many developing countries. These conflicts may foreshadow more violence in coming decades, particularly in poor countries where shortages of water, forests, and fertile land are already producing considerable hardship. Unlike non-renewable resources, such as fossil fuels and iron ore, renewable resources are linked in highly complex systems, and the overuse of water, soil or forests can lead to many unforeseen, simultaneous environmental crises. Scarcities often produce insidious and cumulative social effects, such as large

migrations and economic disruptions that in turn lead to ethnic strife, civil war, and insurgency.

As just one example, in January 1994, dozens, perhaps hundreds, of people were killed in battles between the Zapatista National Liberation Army, a group of about 600 armed men, many of Mayan descent, who declared "war" on the Mexican Government in a battle for the rights of native peoples. The ZNLA took over at least four towns and called for land reform and a new government on New Years Day, the day after the North American Free Trade Agreement (NAFTA) went into effect. They charged that NAFTA, which lifts protectionist barriers and ensures free trade between Canada, the United States and Mexico, would be a death sentence for indigenous peoples.

And in Baidoa, Somalia, as national security broke down looters wrecked Somalia's new national seed bank, in a direct attack on the country's treasury of native genetic material, and emptied underground seed stores of sorghum, the local grain staple. The farmers had planted hundreds of varieties of their staple food crops, adapting these to the local conditions. Further, the raiding soldiers and other armed gangs often were recruited from among nomadic herdsmen clans, who made special targets of farmer clans, their age-old rivals. In the famine that followed the rural rampages, farm families often ate any remaining seed and then fled to nearby towns for food, leaving their fields uncultivated and the agricultural chain broken.

Environmental mismanagement is an important contributor to increasing conflicts (Homer-Dixon, 1994-1995; Graeger and Smith, 1994; Swain, 1993; and Westing, 1986 and 1993). While environmental scarcity is never the sole cause of conflict, scarcity powerfully interacts with economic, political, and social factors to contribute to conflict. Environmental scarcity can lead to declining agricultural production, economic hardship, migrations of people from areas of environmental stress, and tensions within and among groups -- a melange of factors that contribute to violent conflict. According to ICPF

(1994), "Even in war-ravaged Africa, experience shows that where food is plentiful war is avoided. The converse is also true. Historically, war and civil strife have been the single greatest cause of famines. In addition to destroying crops and food supplies, it disrupts food distribution through the use of seizures and blockades. In the past decade, war has had a greater impact on food supplies in Africa, particularly the Sahelian region, than have the severe droughts that periodically plague the continent".

When environmental scarcity reduces the ability of states to meet the needs of their population, dissatisfaction can lead to declining state authority which in turn nurtures violent collective action and repressive responses.

Numerous environmental factors play an important role in creating "environmental refugees" (Myers, 1993). For example, 20% of vegetated land in Asia has been degraded since 1945; the figure is 22% for Africa and 14% for South America. Five hundred million people live in countries with chronic water shortages, a number that is projected to expand to one billion by 2010 and 3 billion by 2025. One-third of the earth's land surface is threatened by desertification, and 135 million people are already facing the effects of severe desertification. And 350 million people are projected to be facing absolute shortages in fuelwood by the turn of the century, but by 2010, 40 to 50% of the currently-existing forest cover is projected to be lost. Such statistics indicate the serious security dimensions of the problems of environmental degradation.

The problems are likely to become worse in the coming years. Homer-Dixon (1994) has summarized the point succinctly: "Within the next 50 years, the planet's human population will probably pass 9 billion, and global economic output may quintuple. Largely as a result, scarcities of renewable resources will increase sharply. The total area of high-quality agricultural land will drop, as will the extent of forests and the number of species they contain. Coming generations will also see the widespread depletion and degradation of aquifers, rivers, and other water resources; the decline of many fisheries; and perhaps significant climate change". His research showed that environmental scarcities

are already contributing to violent conflicts in many parts of the developing world. He concludes that these conflicts are probably early signs of an upsurge of violence in the coming decades that will be induced or aggravated by scarcity. He expects the violence usually to be sub-national, persistent, and diffuse. Poor societies are expected to be particularly affected because they are less able to buffer themselves from environmental scarcities and the social crises they cause. These societies typically already are suffering acute hardship from shortages of water, forests, and fertile land.

Many international conflicts in the past have been based on disputes over water, and indications are that water will become an increasingly scarce resource. The river Jordan is perhaps the most dramatic example, but more than 200 major bodies of water around the world are shared by two or more countries, creating the potential for dangerous disputes. According to World Bank figures, some 20 countries today have less than $1000m^3$ of annual renewable fresh water available per person per year, with Djibouti, Kuwait, and Malta having less than $100m^3$ available. By the year 2025, some 34 countries will be below the $1000m^3$ threshold.

Recognition that sites are of international significance for conservation does not protect them from the implications of war, civil insurrection, and other threats to national security. For example, the 1995 IUCN monitoring report to the World Heritage Committee quoted significant damage due to conflicts to the following World Heritage sites: Plitvice Lakes National Park, Croatia; Manas Wildlife Sanctuary, Assam, India; Aïre and Ténéré National Nature Reserve, Niger; Virunga National Park and Kahuzi-Biega National Park in Zaire; and Galapagos National Park, Ecuador.

The close linkage between security and the environment is rapidly becoming a political reality pushed into even sharper profile by the rising tide of people who have sought the safety valve of emigration, often driven from their homes by environmental problems. But as the number of Central Americans, Haitians

and North Africans migrating to North America and Europe in search of work has increased, so has unemployment, racial tension and social conflict in the towns in the North. Similar problems face many countries in the South who receive significant flows of immigrants, including India, Zaire (now Democratic Congo), and many others.

The strain on the United Nations and the incessant calls for more funds for humanitarian relief and peace-keeping is a growing concern of the wealthier nations. The United Nations is also now spending more money on peacekeeping than on development assistance, i.e. more money is being spent on treating symptoms than seeking cures to social conflict. At a time when the end of the Cold War was supposed to bring lasting economic benefits, a new battle threatens to consume even more resources than the previous military conflict, with far greater damage to the environment.

Environmental scarcity contributes to violent conflict, which may undermine national security. Military force is not an adequate response.

In short, national and international security can no longer be conceived in narrow military terms. Ethnic conflict, environmental degradation and pollution, and famine leading to civil unrest or massive migrations of refugees, constitute threats to both social stability and the preservation of a productive material base. Thus stopping soil degradation and deforestation or augmenting food production capabilities in deficit areas directly and substantially contribute to the security of society, and can help prevent armed conflict. Allocating international resources to environmental monitoring and impact assessment, protection of economically important species, quick response to disasters and accidents, energy conservation, and the minimization and management of waste are all highly appropriate activities that will prevent strife and therefore reduce the likelihood of conflicts leading to humanitarian crisis (Homer-Dixon, 1994-1995).

ENVIRONMENT AND SECURITY: PREDICTIONS

As the natural resource base shrinks in size and quality, social conflicts stemming from resource scarcity will increasingly threaten security at all levels. This may stimulate governments and the private sector to increase investments in environmental security.

While major wars may be less likely, minor wars are likely to multiply, driven by tribalism, nationalism, religion, inequities in resource allocations, and economic factors. Instability is likely to become even more widespread, following models in the former USSR, the former Yugoslavia, Northern Ireland, Rwanda, Sudan, Mozambique, Angola, Zaire, Central America, Peru-Ecuador, Haiti, India-Pakistan, Cambodia, Myanmar, the Middle East, and so forth. Some of these have the potential to have global impacts, especially if highly-destructive modern weapons are unleashed. For example, an editorial page article in the 24 August 1995 International Herald Tribune painted a pessimistic scenario: a fourth war between India and Pakistan over Kashmir, with casualties in the hundreds of thousands; the use of nuclear weapons; and China coming in on the side of Pakistan, with a potential for casualties in the millions.

The revolution in biotechnology and cheap new manufacturing methods will open

strike capacity with devastating results over a wide area. One United Nations study suggested that a ten ton biological weapon could kill 25 percent of the people, and make another 50 percent ill, over an area of 100,000 sq km.

Benford (1994) predicts that runaway population growth in developing countries will lead some people in rich countries to consider humanity as a malignancy, convincing a radical eco-activist to come up with a "designer plague", using biotechnology to custom-design a virulent plague that would dramatically reduce the world's population, convinced that such action was to the benefit of the planet. Recent events in Japan suggest the feasibility of this disturbing prediction.

Philip Abelson, President of the American Association for the Advancement of Science, has predicted that within ten years the US is likely to experience a terrorist nuclear explosion. More generally, the disruptive power of terrorism is likely to increase, sometimes sheltering under the term, "freedom fighters".

The frequency of "ecological terrorism" will also increase, as more people support radical conservation groups such as Earth First! This may lead to a backlash against more mainstream conservation organizations.

2.4. Changes in Climate

The most complex manifestation of human-induced global change is that of the earth's climate. The debate over the effects of ozone depletion and airborne particulates (producing a cooling influence) and greenhouse gases (producing a warming influence) has produced a plethora of scientific material on the subject (summarized and assessed in Houghton, Jenkins, and Ephraums, 1990). In an attempt to deal with the uncertainty in the prediction of the effects of climate change, the Intergovernmental Panel on Climate Change (IPCC) has brought together a group of statements on various climate change issues and the degree of consensus on these issues (Figure 4). Many climatologists believe that the "enhanced greenhouse effect", caused by the observed accumulation of carbon dioxide, methane, nitrous oxide, and chlorofluorcarbons in the atmosphere, is likely to raise mean world temperatures by about 2°C by 2030

and mean sea levels by around 30-50 cm on a comparable time scale (Warrick *et al.*, 1988).

Already, major ice shelves are breaking off Antarctica and for the first time in recorded history it is possible to sail around James Ross Island, formerly connected by ice to the mainland of Antarctica. According to a study by the British Antarctic Survey, continued increases in temperature could result in the disintegration of the larger Ronne and Ross ice shelves which are each roughly the size of Spain. Collapse of these ice shelves could result in land-based ice falling into the sea and cause a rise in the sea level of as much as 5 metres, flooding many coastal cities and causing massive population disruptions.

Although the magnitude and some specific effects (e.g., on clouds or on plankton) of the greenhouse effect remain hotly contested (e.g. Bryson, 1988), the scale and complexity of potential changes has led to a desperate scramble to foresee the future. Large-scale extinctions have occurred as a result of past major climatic changes, cataclysmic disturbances, and human activities (Crowley and North, 1988; Gates, 1993). Although little scientific consensus has emerged on the impacts of apparent current changes, it appears highly likely that global warming and associated disturbance events, particularly when coupled with human population growth and accelerating rates of resource use, will bring further losses in biological diversity (IUCN, 1986; Gates, 1993).

A growing body of research has also examined the possible effects of climate change on individual species and biotic communities. This research suggests that biological communities will change and shift in complex and unpredictable ways as the geographical distributions of species are altered individually rather than in community units (Conner, 1986). Further, because species are interrelated, any advantage falling to a given species in a closed system will affect other species in ways that are not always predictable. The rate of species invasions and extinctions is likely to accelerate further, bringing about complex changes in species compositions and interactions (Lodge,

1993). Thus, rather than causing a simple poleward or uphill shifting of ecosystems with all of their inhabitants intact, climate changes will serve to reorganize biological communities.

For example, small changes in temperature alone may differentially alter the spatial distribution of predator and prey species in marine ecosystems (Murawski, 1993). The 1982/1983 El Niño (a periodic climatic event characterized by inter-annual climate variation in the Pacific Basin and beyond, elevated sea surface temperatures, replacement of upwelling cold water in the Humboldt current by warm water, and changing barometric pressure as far west as Southeast Asia) increased Galapagos rainfall by a factor of ten, with a resultant increase in seed production and caterpillar abundance. Ground finches responded to the increase in food supply by producing up to 10 egg clutches instead of the usual one to five, increasing population size by a factor of four (Gibbs and Grant, 1987). On the other hand, oceanic productivity was low, so that many seabirds did not breed. The Galapagos penguin and the flightless cormorant populations were reduced by 49 and 77 percent, respectively (Valle and Coulter, 1987).

In forest ecosystems, rainfall and seasonality as well as temperature may be influential, particularly if they cause major changes in fruit or seed production. Further, the responses of forests to climate change may depend as much on the indirect effects of climate and vegetation on soil properties (Pastor and Post, 1988). The ability of animal and plant species to shift their ranges in response to climate change also depends on dispersal mechanisms. Significant changes in temperature could occur during the lifetime of some long-lived tree species; trees that disperse light, wind-blown seeds or drop seeds carried by animals may be able to disperse more easily than others (Peters, 1992). On the other hand, tree species dependent on animals for pollination or seed dispersal may be affected by the changing ranges of animal species.

Climates have always been dynamic, but human influences are now driving climate change that will challenge the adaptability of many species. For example, as glaciers retreat, streams may run dry, causing downstream impacts.

Peters and Lovejoy (1992) identify a number of mechanisms through which species and communities are likely to be affected as a result of the direct and indirect impacts of climate change. Populations located near the edge of a species' range, narrowly endemic species, and endangered species that exist only in protected areas or other extremely limited habitats are especially vulnerable to global vegetation shifts. Species that are already threatened by direct exploitation and habitat loss and degradation are likely to be particularly susceptible to new threats. Coastal communities may be inundated as sea levels rise, while altitudinal shifts brought about by increased temperatures would reduce or even eliminate the ranges of montane and alpine species, many of which are already relictual, having been isolated by past climate changes. In zones where genetically distinct populations meet, mate, and produce hybrids,

climate change may favour some species but cause the extirpation of others (Barton and Hewitt, 1989).

Because climate change is expected to be greatest at high latitudes, Arctic communities are also expected to undergo particularly rapid changes. Many of Europe's most productive wildlife habitats are in the far north, where algae, bacteria and other microscopic organisms grow on the undersides of sea ice during the spring. As the ice breaks up with the approach of summer, the organisms are released into the water, where they support a series of food webs that include large species such as whales, polar bears and seals. An increase of 5°C over the next 50 years could melt even the permanent Arctic ice (Pain, 1988), bringing fundamental changes to polar ecosystems. Alexander (1992) notes that the melting of sea ice could also affect marine mammals that use ice floes for rest, travel and reproduction. If an ozone hole becomes established over the north pole, these impacts could be greatly magnified; El Sayed (1988) predicts significant damage due to the sensitivity of some plankton species to increased ultraviolet radiation.

Climate change will also affect people directly. Global warming could lead to the spread of infectious diseases such as cholera, malaria, and yellow fever. *Anopheles* mosquitoes which carry malaria are limited to areas with average temperatures of 16°C, but with global warming, the range of these mosquitoes could be dramatically extended northward (Martin and Lefebvre, 1995). Further, warmer temperatures accelerate the lifecycles of disease-carrying insects, encouraging them to feed more often and therefore infecting significantly more people in warmer weather. One study in Rwanda found that a 1°C temperature rise caused malaria infections to increase by 337 percent.

Extremes in climate help create conditions that can lead to outbreaks in infectious disease. For example, the epidemic of pneumonic plague in India in 1994 was at least partly due to hot, dry conditions which enabled disease-carrying fleas to thrive. And the 1993 outbreak of hantavirus in the south-western United States appears to have been caused at least partly by extreme

climatic events over the previous six years which produced an abundance of the foods that disease-carrying rodents prefer; but the drought, accompanied by federally-funded predator-control programmes, had killed off many of the normal, but slower-breeding, predators of the rodents -- again showing how unbalanced ecosystems can have profound, and unpredictable, effects.

Figure 4. Degree of Consensus on Various Climate Change Issues (IPCC, 1992)

Issue	Statement	Consensus
Basic characteristics	Fundamental physics of the greenhouse effect	Virtually certain
	Added greenhouse gases add heat	Virtually certain
	Greenhouse gases increasing because of human activity	Virtually certain
	Significant reduction of uncertainty will require a decade or more	Virtually certain
	Full recovery will require many centuries	Virtually certain
Projected effects by mid-21st Century	Large stratospheric cooling	Virtually certain
	Global-mean surface precipitation increase	Very probable
	Reduction of sea ice	Very probable
	Arctic winter surface warming	Very probable
	Rise in global sea level	Very probable
	Local details of climate change	Uncertain
	Tropical storm increases	Uncertain
	Details of next 25 years	Uncertain

Virtually certain: nearly unanimous agreement among scientists and no credible alternative view
Very probable: roughly a nine out of ten chance of occurring
Uncertain: Hypothesized effect for which evidence is lacking.

Despite the consensus of climate scientists, the climate system is still unpredictable and may contain hidden dangers for people. For example, the Gulf Stream is what keeps Europe wet and warm rather than being as cold as Canada (Madrid is as far north as New York, while London is as far north as Hudson Bay). In response to greenhouse warming, northern Atlantic surface salinity is highly likely to decrease, leading deep water production to drastically decrease in the ocean just south of Iceland, and causing surface temperatures to drop, thereby deflecting the Atlantic current and leading to a significant global cooling and perhaps start another ice age. This could lead to famine in Europe, with unpredictable, but certainly unpleasant, consequences.

CHANGES IN CLIMATE: PREDICTIONS

Interactions between the biosphere and climate will become much better understood as increasingly-sophisticated technical means are developed to measure the chemical composition of the atmosphere, and changes to it as a result of human actions. This increased understanding will enable better planning for adapting to the changes, though it seems unlikely that climate management will become a reality within the foreseeable future.

Major changes in global vegetation cover are expected to occur in response to global climate change, primarily as a result of changing temperature and precipitation (Gates, 1993). Rising temperature and precipitation will result in the expansion of boreal forests, but overall forest area is expected to shrink, with grasslands and deserts increasing in extent (Schlesinger, 1991). In North America, Europe, Asia and southern Africa, desert and other areas of sparse vegetation may expand at the expense of grasslands, shrublands, and prairies. On the other hand, shrubby vegetation may spread into areas of sparse vegetative cover in southern Africa, Saudi Arabia, and Australia (Woodward, 1992).

By the end of the next century, global average surface temperatures are predicted by the IPCC (1992) to increase by 2-6°C with an attendant rise of sea level of 0.5-1.5m; such a change would be 10 to 50 times faster than the natural average rate of temperature change since the end of the last glaciation (Schneider, 1989). These changes could bring increased frequency and destructiveness of hurricanes (Emanuel, 1987); more protracted droughts, longer and hotter heatwaves, and more severe rainy periods; and significant changes in the area of the great ice sheets of Antarctica (Frolich, 1989).

Perhaps the biggest challenge is that problems of biodiversity and climate change lie in the deeply-ingrained everyday behaviour of people, especially in their patterns of consumption of the fossil-fuel energy whose by-product, carbon dioxide, could heat the atmosphere and make the global climate more unstable and disruptive. It is an open question whether even complete knowledge about the causes and future impacts of climate change would lead to significant changes in human behaviour in time to avert the predicted changes. And even if people fundamentally changed their behaviour today, the effects on climate would still be several decades into the future.

2.5. Changes in Environmental Pollution

Pollution is clearly a major concern for humanity, especially in industrial societies where environmental protection measures have been inadequate (such as eastern Europe). Pollutants stress ecosystems and may reduce or eliminate populations of sensitive species, as contamination may reverberate along food chains; for example, many remote arctic lakes contain a wide range of pesticides that may be toxic to humans, apparently resulting from a global distillation process in which chemicals are vaporized from soils as far away as the tropics and transported by wind to the far north, where they condense out and become concentrated in the body fat of animals at the top of the food chain -- including fish, seals, and humans. One recent study in Canada found that pesticide concentrations were highest in fish from lakes with the longest food chains -- in other words, the lakes with the greatest biodiversity, at least as measured by ecosystem complexity.

Acid rain has made thousands of Scandinavian and North American lakes virtually lifeless, and, in combination with other kinds of air pollution, has damaged forests throughout Europe; developing countries such as Brazil, India, and China are also increasingly suffering from acid rain. Marine pollution, particularly from non-point sources, has defiled the Mediterranean and many estuaries and coastal seas throughout the world, leading to impacts

on reproduction of some marine species. The key point here is that pollution is far more than a human health issue -- it has significant impacts on conservation as well. For many conservation organizations, pollution is an area of particular concern; yet other conservation organizations, such as IUCN, have tended to avoid becoming involved in this issue, at least partly because of the investment required to build up a sufficient capacity to respond credibly to the multiple sources of threats.

Environmental pollution is basically a side-effect of resource consumption, the result of converting useful resources into substances that are hazardous to human welfare. Most global-scale impacts of pollution have been quite recent, especially those dealing with biogeochemical cycles. For example, industrial emissions alone now multiply the annual natural releases of arsenic by a factor of three, of cadmium by seven, of mercury by ten, and of lead by 25 (Kates, *et al.*, 1990).

Much of the pollution is related to energy consumption. Early humans consumed just enough energy to keep alive, like other animals. When they began to cook food, energy consumption doubled, only to triple again when they started to cultivate crops. Today we each consume about 125 times more energy than our early ancestors did. Although we still need to cook and keep warm, most of the energy is used to maintain a pampered and convenient lifestyle (Hill *et al.*, 1995).

Other pollution-related problems are more subtle. Colborn *et al.* (1996) warn about the effects of synthetic chemicals that mimic the effects of hormones in humans and all other vertebrates. They argue that a bewildering array of hormone-mimicking chemicals threatens our survival, that infertility found earlier in wild mammals and birds was the harbinger of problems that now affect humans. Since the 1940s, increases in the rates of breast cancers and ectopic pregnancies have been matched by a precipitous drop in sperm counts. These chemicals could even produce future generations of children who are increasingly stupid, quarrelsome and aggressive. Chemicals that mimic

hormones include DDT, polychlorinated biphenols (PCDs), dioxine and the alkylphenols (used to stabilize plastics). They are persistent in the environment and appear to cause damage at minute concentrations; they attack organisms at their most vulnerable time, when they are embryos. Hormones controlling the metamorphosis of a tadpole into a frog are the same as those that control human sexual development, so if these pollutants are causing the worldwide decline in frog populations, they might also be responsible for increases in human diseases that are related to hormonal disruption. And since development of the brain is largely under hormonal control, the explanation of increasingly violent behaviour, inattentiveness, and various other social problems might be explained by these hormone-mimicking chemicals. We might not discover the true dimensions of this problem until it is too late.

While pollution has been brought under better control in at least some countries, pollution remains a pervasive problem with subtle and unknown long-term effects on humans and other species.

At least some of the pollution problems can be solved; industrial emissions can be reduced with present technology at reasonable cost. For example, the technology is available to significantly reduce the energy requirements of industry and other economic activity, so that carbon emissions can be reduced without necessarily implying a reduction in standards of living (Goodland, 1991). Since 1973, for example, Japan has increased its industrial output by 81 percent without increasing energy use. Mills *et al.* (1991) conclude that even allowing for continued economic growth, by the year 2000 global greenhouse gas emissions can be reduced by 10 percent from current levels, at significant net economic benefit, through implementation of available energy-efficiency improvements. The impacts of ozone pollution on crop production can also be reduced by reducing the use of fossil fuels, limiting losses of nitrogen fertilizers from soils, implementing nitrogen-oxide emission controls, and developing ozone-resistant crops. Enhanced networks for monitoring air quality throughout the world to assess the extent and severity of ozone pollution on continental scales will aid in evaluating the benefits of these mitigating strategies (Chameides *et al.*, 1994). The real issue now is one of political will.

Early environmental regulations focused on large problems where big benefits -- especially in the field of pollution -- easily exceeded costs. But now growing costs may outweigh dwindling gains, leading to a backlash on the part of politicians (and the general public). Optimists will point out that environmentalists have won important victories, such as stopping the flow of raw sewage into waterways, but pessimists will respond that it is much more difficult to control the broad run-off of fertilizers, silt and pesticides from farm fields and urban developments; and these may be even more devastating to aquatic life and ultimately to human welfare.

A critical problem looming on the horizon is the export of hazardous waste from developed to developing countries, and the proclivity of many governments to locate hazardous waste dumps in areas inhabited by indigenous

peoples or other under-privileged groups. Vigilance and public information campaigns will be required to ensure that such practices do not continue and expand.

CHANGES IN ENVIRONMENTAL POLLUTION: PREDICTIONS

By 2025, emissions of fixed nitrogen from fossil fuel and biomass burning are expected to increase over 1980 levels by 25 percent over North America, by more than half over the oceans of the Northern Hemisphere, and at least 100 percent in the developing areas. Less than one-third of this increase will be based on population growth, with the remainder resulting from greater per capita emissions, especially in the developing world. The increases in nitrogen deposition will lead to greater fertilization of terrestrial and marine ecosystems, increases in acidification, and increases in emissions of nitric oxide and nitrous oxide (Galloway, *et al.*, 1994).

Exposure of agricultural crops to yield-reducing ozone pollution may triple by 2025 if rising anthropogenic nitrogen oxide emissions are not abated. The increase in ground-level ozone pollution will have strong negative impacts on agriculture at the very time when growing populations and levels of consumption are putting pressure on the capacity to produce food.

Principles of ecology will be utilized in the design of both business programmes and public policies designed to steer the market place toward pollution prevention, source reduction, and efficiency. Reducing pollution and waste will help encourage businesses to drive these factors toward zero, earning a return on their investment which could range from 30 to 100 percent or more (Shireman, 1995).

2.6. Changes in Economics

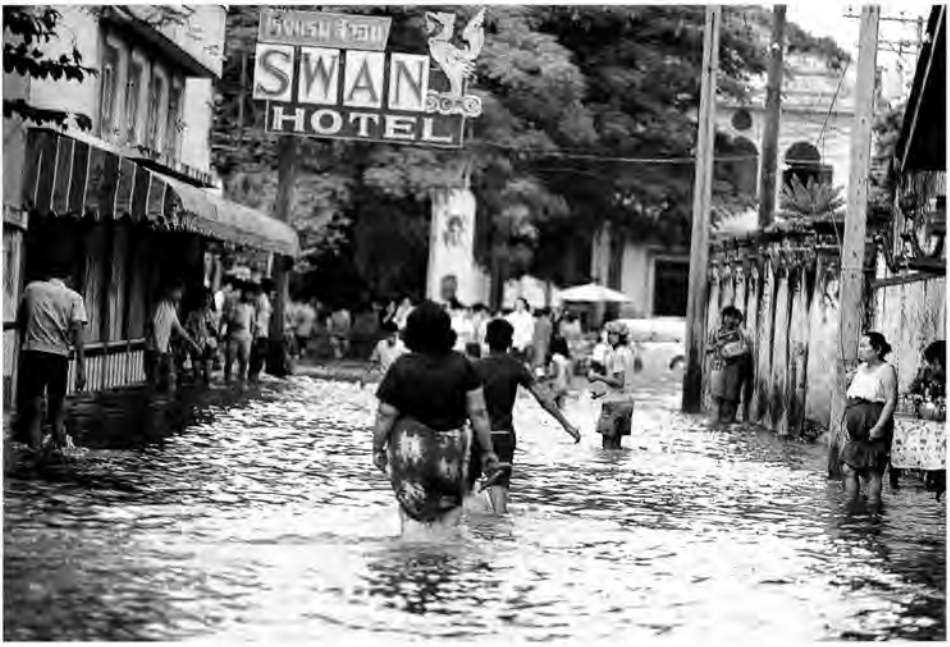
Many cornucopians link their technological optimism to economic arguments, for in an era in which natural capital is the limiting factor to economic development, logic dictates that we maximize its supply and productivity

(Daly, 1990). Further, the world's shift from command to market economies offers greater opportunities for research and investment, since market economies are generally more open to change in response to signals of ecological distress (MacNeill *et al.*, 1991; Ausubel, 1993).

The world may be reaching a time of profound change in the structure of the way society functions. Historically, people often experience such restructuring as a depression, but optimists might contend that "structural adjustment" and global capital flows are making the process slightly less painful. Of course, the developing countries who are having their structures adjusted often feel manipulated by the economic powers of the North, quoting problems of indebtedness, unfair trade conditions, and conditionality (Comisión de desarrollo y medio ambiente de America Latina y el Caribe, 1990). The advanced industrial countries avoided the worst of the economic crisis of the 1980s largely by creating public and private credit, leading to severe indebtedness and ultimately to bad debts, bankruptcies, bank failures, reduced jobs, and lack of consumer confidence. But these structural changes will, the optimists contend, lead to increased prosperity by 2025, based on new technologies, industries, institutions, and geopolitical configurations (Ausubel, 1993).

Cleveland (1995) concludes that people governed by consent seem to want to do business (shop, invest, work, watch television) across borders that are as open as possible. This ensures a growing role for global companies, already the most dynamic actors in international economic affairs. It also seems bound to accelerate the leakage of power from central governments to international regulators and cooperation systems, to international non-governments (not only the global companies but also well-organized associations of professionals, such as the international communities of scientists, lawyers, and economists) and to sub-national authorities and enterprises where local governments increasingly take the initiative on issues that used to be pre-empted by central governments (see 2.7).

Globalization has helped stimulate greater consumption of resources and the growth of cities as trading centres. But cities remain vulnerable to environmental disruptions to which people contribute.



This globalization of markets is a major conservation issue because it leads to a lack -- or at least a weakening -- of feedback loops. For example, in the field of banking, the trend is toward fewer and larger banking conglomerates, with less and less diversity and ties to specific local situations. It is apparent that decision makers in today's world do not have an effective feedback loop with the environment, as they are surrounded by noise from the clamouring crowds of competing interests; a crucial measure would be reforms that would improve the economic signals that are received by resource users.

As the concept of national markets has been replaced by regional trading blocks, the relative importance of the private sector, including national and multi-national industry, has greatly increased. This globalization of the economy has been accompanied by at least a recognition of the

interdependence of the world economy with the environment, an interdependence that is underlined by such conflicts as the "cod wars" in the North Atlantic, transboundary transport of toxic wastes, nature-based tourism, trade in endangered species, and numerous international agreements.

The recent establishment of the World Trade Organization and the growing size and importance of multi-national corporations make it inevitable that the world will increasingly become a single marketplace, with profound implications on culture, resources, security, and human welfare. The economic centre of gravity is shifting from the north to the south, as many economies in Asia and Latin America are showing unprecedented annual growth rates. China is today the world's second largest economy, with India sixth, and Brazil and Mexico in the top ten. Much of this economic growth in the south is driven by exports to the north, matched by exports of manufacturing jobs from north to south; but it depends on a globally-shared orientation toward production of more consumer goods. Herman Daly and others have pointed out the dangers inherent in such a global marketplace, which tends to promote local over-exploitation of resources because it is not able to detect the symptoms of over-exploitation until it is too late to change the trajectory of use, instead shifting easily to new resources when the old ones are depleted. Under current economic arrangements, the market is less sensitive to ecological changes than to most other sorts of change.

A broadly-accepted observation is that as a nation's income goes up, environmental degradation also increases up to a point, after which environmental quality improves (the "Environmental Kuznets Curve"). This has been found to be the case especially for emissions of pollutants, but less so for resource stocks where feedback effects are significant, such as those involving soil, forests, and other ecosystems. For example, the fact that each American accounts for the consumption of 52 kg of physical materials each day, as opposed to 1.5 kg of locally-collected biomass by the 1 billion poorest inhabitants of our planet (Durning, 1991) makes it clear that the argument that poverty is a primary cause of environmental destruction -- and that economic

growth is the key to increased environmental responsibility -- is clearly perverse (Korten, 1994); though of course, poverty does have significant impacts on the environment when it forces landless poor on to lands that are marginal for agriculture. Arrow *et al.* (1995) have found that in most cases where emissions of pollutants have declined with rising income, the reductions have been due to local institutional reforms, such as environmental legislation and market-based incentives to reduce environmental impacts. But such reforms often ignore international and inter-generational consequences; where the environmental costs of economic activity are borne by the poor, by future generations, or by other countries, the incentives to correct the problem are likely to be weak. The environmental consequences of growing economic activity, may, accordingly, be very mixed. Therefore, solutions are likely to be found in institutional reforms that would compel private users of environmental resources to take account of the social costs of their action. This has certainly happened in the past, but it may not happen in time to avert the important and irreversible global environmental consequences of growth.

Arrow *et al.* (1995) conclude that, "Economic growth is not a panacea for environmental quality; indeed, it is not even the main issue. What matters is the content of growth -- the composition of inputs (including environmental resources) and outputs (including waste products). This content is determined by, among other things, the economic institutions within which human activities are conducted. These institutions need to be designed so that they provide the right incentives for protecting the resilience of ecological systems. Such measures will not only promote greater efficiency in the allocation of environmental resources at all income levels, but they would also assure a sustainable scale of economic activity within the ecological life-support system. Protecting the capacity of ecological systems to sustain welfare is of as much importance to poor countries as it is to those that are rich".

One of the most important underlying causes of environmental problems is market failure, what the pioneer economist Adam Smith might have called "the

invisible backhand". Much current work indicates that economics will provide increasingly useful tools for improved conservation, addressing local market failures by capturing and internalizing to local populations the benefits from the goods and services derived from the environment. Increasing supply from available resources, mitigating ecological damage associated with human activities, and developing adaptive technologies depend in large part on the ability, and willingness, of governments to reform economic pricing and markets. Markets and prices must not only account for the environmental costs of production and consumption, but also compensate economic sectors for the environmental benefits of resource conservation (McNeely, 1988; Dogse and von Droste, 1991). Brenton (1994) considers that sustainable development will not emerge from "dense webs of regulation" or the old command and control approach to environmental conservation, but only when conditions create more democracy, greater economic prosperity and a market that works for, rather than against, the interests of biodiversity. However, it is increasingly clear that the process of market reform and "getting prices right" involves much more than simply freeing the market. Markets are the creation of human cultures, policies and institutions and are therefore subject to the many limitations of human understanding and politics.

The World Bank, which has become a mainstream environmental organization, is working on new economic approaches to ensuring that economic development is not an enemy of the environment, and that the best policies for environmental protection will help, not hurt, economic activities. A 1995 World Bank publication entitled "Monitoring Environmental Progress, a Report on Work in Progress", presented a new way for countries to measure their economic well-being, breaking national wealth into four major attributes:

- √ Produced capital, the economic value of machinery, factories, roads, water systems, and other aspects of a nation's infrastructure;

- √ Natural capital, consisting of the value of standing timber, proven or reasonably predicted mineral deposits, land, water, and other environmental assets;
- √ Human resources, including such factors as the education level of the population, health care, nutrition, longevity, and so forth;
- √ Social institutions, such as secondary mortgage markets that provide economic opportunity for the population.

The key point for conservation organizations is that economics needs to become a tool for conservation, involving full-cost accounting, green taxes, economic incentives for conservation, and "internalizing environmental externalities". Ways must be found to send conservation-oriented signals to the marketplace and to stop subsidizing the destruction of nature.

CHANGES IN ECONOMICS: PREDICTIONS

Central governments will grow relatively smaller; markets will grow larger and more important; and the world economy will continue to be international, thereby masking some of the feedback effects of smaller markets. The private sector, especially multinational corporations, will become far more powerful. But these trends are based on a fragile foundation and the cycle could easily turn to greater protectionism and centralization, perhaps as a response to deteriorating security conditions.

The balance of economic power will continue to shift toward east Asia, while Africa will continue to lag well behind.

Economic tools that will be used more in the coming years include lowering forest protection costs, using water fees as ecosystem conservation incentives, internalizing ecotourism benefits, providing incentives for reforestation, applying differential land use taxes, requiring environmental performance bonds, agreeing on forest compacts, and expanding the use of transferable development rights and conservation easements. Such economic tools are being actively developed and will be increasingly useful in the future.

The trend toward the use of market or economic incentive mechanisms in the

conduct of environmental policy, seeking to internalize environmental costs, will accelerate.

Development assistance flows will decline substantially, while corporate sector flows may increase. According to a UNEP global survey, the number of banks throughout the world involved regularly in environment-related investment and lending will triple over the next 15 years, to include well over three-quarters of all investment and commercial banks.

Tourism will become a dominant economic sector. Today 212 million people are employed in travel and tourism, a business that earns $3.4 trillion annually. In 1994 the number of international air passengers stood at 339.6 million, with 100 million more expected by 1998. The number of airline passengers travelling to and from Europe will more than double by the year 2010, to 841.9 million, from 400.3 million in 1993, according to a study by the International Air Transport Association. A decade from now, the tourism industry is expected to employ 338 million people and have revenues of $7.2 trillion. The overwhelming expansion will be in the middle class, and especially in the field of adventure tourism, or tourism to the very destinations that conservation organizations are often working to conserve.

2.7. Changes in Institutions

The main institutional actors in the conservation field include the private sector, with its emphasis on marketplace agility, the bottom line, and the public's expressions of preference; the public sector, with its emphasis on stable and codified process, regulating private action, protecting public goods, and reluctance to experiment; and the independent sector, with its tradition of innovation, critical thought and the checking of inequalities of wealth, status, power, and knowledge (Ausubel, 1993).

The Greek philosopher Aristotle (384-322 B.C.) studied the constitutions of 158 states, past and contemporary, in and around the Mediterranean. He concluded that states pass through an endless cycle, each stage of which contains the seeds of its own destruction and thus prepares the way for the next

stage. Government by a single all-powerful ruler, with truth handed down from a supernatural source, is followed by government by aristocracy, with an organized, systematic faith backed up by reason. This is then followed by government by an elite, with an emphasis on human relationships and conduct in religion; democracy then follows, where science is all important and doubting and questioning become an important part of social discourse and right and wrong are no longer overriding, but are related to circumstances. Aristotle concluded that democracy is followed by anarchy, characterized by selfishness, distrust, and lack of faith, which in turn yields to tyranny characterized by trust in factions and the seeking of short-term gains by any means. Societies escape tyranny through strong leaders who are seen as saviours, leading to legalized despites who find truth from prophecy, oracles, and other supernatural channels. This leads back to government by the single all-powerful ruler, and the cycle begins again. While conditions have changed somewhat over the past two millennia, the cycle seems to have stood the test of time reasonably well, and many of the intellectual attitudes sound hauntingly familiar. Without trying to conclude that such cycles are necessarily inevitable, cycles are familiar phenomena in economics, ecology, and politics. But since the time of Charles Darwin, modern society has come to appreciate that evolution is also possible, holding open the hope for progress, possibly through cyclic changes, rather than the less intellectually-challenging linear changes which many observers seem to prefer.

As suggested in section 2.6, the nation-state is no longer the principal definer of the marketplace, especially as the marketplace goes regional and global. Many structures and networks are being created and maintained by their ability to help people to communicate, irrespective of public authority. Many of these "non-governments" have become effective users of modern information technologies, and in fact groups concerned with business and finance, population policy, human rights, various aspects of science, and so forth, are highly creative in using information technology and therefore are providing more and more of the policy initiative at both domestic and international

levels. Thus, we can expect the role of central governments to continue to change from primary determinant of the society's course to that of coordinator, regulator and monitor of the activities of local governments, the private sector, and NGOs. Power will be more broadly shared, and the role of the marketplace will become more dominant in establishing the conditions under which development can be made sustainable and resources conserved. The expansion of regional and global economic infrastructures also permit the reawakening of local identities and may stimulate an increasing interest in both cultural and biological diversity (as well as various sorts of conflict). The general trend is one of global integration but simultaneously greater local autonomy and responsibility. Managing this apparent paradox will be a major challenge in the coming years.

The UN system, the World Bank, and the International Monetary Fund were established in the post-war era when the nation-state was supreme, and were designed to serve the interests of central governments. Consequently, not only are these institutions modelled on the nation-state, but they reflect its limitations; the existing international institutional framework is not well designed to cope with the new realities. It was built around the perceptions and approaches of national government structures and therefore these institutions are, in general, slow to react and position themselves to build upon the opportunities that have come with the formation of wider regional alliances, powerful multi-national corporations, and trading blocs. Similarly, they are slow to benefit from opportunities provided by the decentralization of authority to local government structures, and devolution of initiative to community groups such as people's associations and other community-based organizations. The change in the role of the nation-state which the organizations are designed to support means that their role will also change; it should be remembered that in global economic terms, the UN system already is minute, expenditure being around one-twentieth of one percent of global GDP or just over one percent of global military expenditure; more people work for the government of Winnipeg, Canada, for example, than for all of the United Nations. Bilateral

development assistance agencies suffer, albeit to a lesser extent, from the same shortcoming since they too were designed to interact with central governments in recipient countries.

Multilateral intergovernmental institutions are lagging far behind modern challenges, providing ex post legal regimes and the often-inefficient mechanisms to administer them. People are more aware than ever before of the impacts of modern society on the environment, especially through the use of television; but the one global inter-governmental institution that has been established to deal with the issues -- namely the United Nations Environment Programme -- is being progressively weakened by lack of political support from its member states and its own inefficiencies. The international institutions which remain firmly wedded to national governments are in danger of presenting an obstacle to progress, occupying a niche which prevents more adaptable and flexible institutional arrangements from arising.

While the traditional institutions, such as banks, botanic gardens, and the World Bank play important roles in conservation, they are not always well adapted to the rapid social changes taking place around them.

The mechanics of the new global system are becoming increasingly apparent, being led by modern information technology and with a greatly expanded role for the private sector in both the financial and service industries. As the relative importance of central governments continues to decline, at least some of their roles will be augmented by other forms of association, such as multi-national corporations, multi-national membership organizations such as economic and defence alliances, NGOs or other forms of organization with large membership bases and considerable resources and/or political power. A possible problem with such privatization is that governments are public and can be scrutinized by the public, but the private sector is much more difficult to control and much more skilful at managing public opinion (but also consider the power of Greenpeace to embarrass powerful multi-nationals, such as Shell). Another problem is that the private sector has not yet shown itself able to protect the common interest, especially in the case of public goods which are not able to be protected by private interests.

The key institutional issues in the coming decades will include devolution of power and responsibility, decentralization, privatization, commercialization, and constantly changing relationships among institutions. Legislation is a likely to proliferate, leading to calls for reducing regulation; and at the same time, international legislation may become increasingly important as a counter-balance to the global marketplace and information superhighway.

Changes in the independent sector, basically NGOs, will be especially important for conservation organizations, as they seek to continue providing linkages among the three main institutional actors; on the other hand, communities are likely to have more direct access to the decision-making process, so the role of NGOs as intermediaries may decrease. In the meantime, NGO numbers have increased remarkably over the past two decades, especially in Europe, North America, Asia and Latin America. In some countries, particularly in parts of Asia, it is even conceivable that NGOs will play an increasingly important role as extensions of government. In other

words, governments may well slim down their bureaucracies and pass the work through to the NGOs and corporate sector on a commercial basis. The Middle East and Africa have lagged behind in this change, although the NGO movement is now gathering momentum in parts of Africa. In Europe and North America, it is possible that NGOs might decline in numbers and in strength as the public either tires of their messages or perceives the inevitable contradictions, duplication and inefficiencies. All of this will lead to a new emphasis on partnerships, alliances, and other arrangements that will enable groups to reach a critical mass to achieve their objectives.

CHANGES IN INSTITUTIONS: PREDICTIONS

Governments will become increasingly decentralized, focusing on developing policies and decreasing their capacity in natural resource management. Ironically, the decade of the 1980s witnessed attempts by most donor agencies to support "institutional strengthening" which meant more and better-trained staff in government ministries; the decade of the 1990s, with structural adjustment, has seen many of those staff losing their jobs. It is highly likely that resource management will be returned to those living on the land, with government intervention being much less prominent. The institutional strengthening required will be at the level of communities and local authorities, often seeking to resurrect local institutions that were suppressed in the period of all-powerful central governments.

The frustration with the United Nations system will continue to grow until it leads to a climax of revolutionary change as the world community seeks new leadership that reflects the concerns of the private sector, the public sector, and the independent sector.

New religions and charismatic religious leaders will emerge in the future climate of uncertainty, risk and change. And established religions may also become stronger. For example, the International Herald Tribune of 23 September 1995 reported that Hindu worshippers were claiming that stone idols had begun drinking milk offerings, with the increased demand leading to a 15-fold increase in the price of milk in some Indian cities. Devout Hindus believed that their gods Shiva, his consort Parvati, and their son Ganesh, were returning to Earth to solve everyone's problems. The phenomenon spread

quickly to Hindu temples as far away as London, Singapore, and Hong Kong.

The environmental movement has succeeded in passing the core elements of command-and-control environmental regulations, but in the coming years will increasingly shift to a post-industrial, incentive-based approach. The competitiveness movement and revolutionary advances in productivity within the business community will increasingly create a culture of business advocates who recognize the value of a post-industrial policy environment that creates incentives for constantly improving efficiency.

Policy will be restructured to emphasize the use of economic and market instruments, promote flexibility, and place more decision-making power at the local level. Such changes will offer an opportunity for government, industry, and the public to consider a wider range of policy options, thus enabling more effective tools to be selected for developing and implementing conservation policy (Sahl and Bernstein, 1995).

2.8. Changes in Technology

All major development goals, including economic growth, environmental protection, improved health, better farming, and improved human welfare, depend on the ability of countries to absorb and use science and technology. Unforeseen technological breakthroughs could have profound and unpredictable effects on society -- consider the impact of computers, nuclear weapons, and satellite communications. The key role of technology is one reason why "technology transfer" is such an important topic of discussion at intergovernmental negotiations (e.g., Article 18 of the Convention on Biological Diversity). However, much of the new technology is essentially beyond the reach of governments. Kennedy (1993) argues that the main creators and controllers of technology have increasingly become large multinational corporations with more global reach than global responsibility. They are the groups that create, control, and have access to new discoveries, and they are increasingly able to operate free of direct government control, responding instead to their customers and stockholders.

Technology can provide the key means for adapting to change, but modern technologies such as genetic engineering can also bring about unanticipated changes.

Rennie (1995) points out that a good technology must by definition be useful; it must be able to survive fierce buffeting by market forces, economic and social conditions, governmental policies, quirky timing, whims of fashion, and all the vagaries of human nature and custom. International disputes over who owns the mineral rights to the sea floor sapped the incentive that many nations and corporations had to invest in undersea mining technologies. Competing industrial standards can also hamper progress, as illustrated by the conflicts that froze work on high-definition television. Many of the greatest innovations are unforeseen, if not unforeseeable; for example, a Technology-of-the-20th-Century Symposium held in 1895 might have not mentioned airplanes, radio, antibiotics, nuclear energy, electronics, computers, or space exploration. Can anyone today truly foresee what the world will be like if, for example, genetic

engineering matures rapidly to its full potential? If organisms can be tailored to serve any function, can anyone guess what a mid-21st century factory will look like?

Technological optimists often argue that even given recent evidence of the pace and scale of environmental change, human societies can continue to achieve quantitative and qualitative economic development through advances in science and technology. Technological innovation undoubtedly has the potential to dramatically stretch the limits of existing resources and systems in order to meet the needs of present and future human populations, and to alleviate many of the ecological and economic stresses caused by growing human populations and rising per capita resource consumption. Currently, computer chips are getting twice as powerful while halving in cost every 18 months. Crop improvements and continuing improvements in irrigation and pest control are likely to enable rising productivity as well as reducing known environmental impacts; for example, research is now underway to develop drought-resistant cassava and crops suitable for production on acidic soils (El-Sharkawy, 1993; Rao *et al.,* 1993). Continuing increases in food supply can also be maintained through increased aquacultural production as well as diversification of seafood consumption. Timber consumption can be reduced dramatically simply by further development of technologies to reduce waste or to mass produce woodless paper (Postel, 1994).

As the rate and scale of global change have increased, so has the technological response. One of the most dramatic manifestations of a technological response to resource limitations is biotechnology, which offers the prospect of boosting crop yields with lower inputs of energy, water and pesticides. In the short term, potential advances which appear likely include modification of food crops to increase resistance to insects, viruses and fungi; improve processing quality or reduce spoilage; and improve nutritional content. Fermentation and enzyme technology are already used in the manufacture of animal growth hormones to increase milk production or induce faster growth and production of leaner meat. In the long term, biotechnology may help to offset the impacts of global

change on food supply, for example by producing staple crops that are resistant to drought, heat and other environmental stresses. New reproductive techniques for livestock, such as embryo transfer to stimulate production of multiple eggs for artificial insemination or cloning, could boost the reproductive rate of desirable species and reduce susceptibility to disease (WRI, 1994; Teale, 1993). And already a multinational corporation, CIBA Agriculture, has developed a spray which can immunize crops such as wheat, bananas, and rice against fungal infections in much the same way that people can be vaccinated against disease; applied at a dosage of 30 grams per hectare, this biotech breakthrough could prove to be very important in maintaining yields.

Biotechnology also offers the possibility of new production techniques that reduce emissions of chemicals and metals into the environment. Researchers have discovered that a completely biodegradable natural plastic is produced by some types of bacteria, which can be grown in large batches to harvest the plastic. Eventually, it may be possible to insert the genes into crop plants from which plastic could be harvested. Mass production of natural plastics could replace petroleum-based products in the marketplace as well as easing problems of solid waste disposal (WRI, 1994; Frederick and Egan, 1994). Production of ethanol from waste materials, microbial coal desulphurization, and algae-fuelled combustion could reduce emissions to the atmosphere of chemicals contributing to acid rain and the greenhouse effect.

Biological elements are also used to detect organic chemicals, pesticides, and mercury in the environment, while bioremediation is increasingly used as a technology for cleaning polluted sites of metals and pesticides and treating acid drainage from coal mines. Biofilters are used to remove volatile organic compounds from industrial emissions, while bioleaching can lessen the environmental impacts of mining by enhancing recovery of minerals and reducing the release of metals into the environment (Frederick and Egan, 1994).

It is becoming increasingly clear, however, that even rapid advances in productive and environmental remediation may not be sufficient. For example, increasing aquacultural output on the scale needed would require vast amounts of water and feed, and accelerate loss of coastal mangrove habitat (Brown, 1994; WCMC, 1992). Further, the energy use and habitat modification associated with aquaculture also contribute to changes in the earth's atmosphere and climate, which will in turn bring about dramatic changes in coastal ecosystems.

Biotechnology also brings its own set of problems and challenges. In the past, human activities have resulted in biodiversity loss through the introduction of exotic species, a problem that could recur on a grander scale with the introduction of transgenic species. Altered organisms may out-compete other species in the environments in which they are released, or spread their altered genes by reproducing with native species (WRI, 1994; Pimental *et al.*, 1989; Hoffman, 1990). Just as the Green Revolution was accompanied by hidden economic and environmental costs, the Biotechnology Revolution undoubtedly will bring with it environmental consequences that have not yet been anticipated. For example, some developing countries are concerned that biotechnology will enable the developed countries to reduce their imports of some agricultural commodities from the developing countries, with unpredictable effects on the environment (Comisión de desarrollo y medio ambiente de America Latina y el Caribe, 1990).

The new biotechnology, which is vastly powerful, is not accepted by all. A group of noted American chefs, for example, has banded together to agree to not use any genetically modified organisms in their cooking. And many mainstream religious leaders are starting a campaign against the patenting of human genes and genetically engineered animals. This puts them in direct opposition to a policy that the biotechnology industry considers crucial to commercializing biotechnology. One religious leader was quoted as saying, "I think we're on the threshold of mind-bending debates about the nature of human life and animal life. We see altering life forms, creating new life forms,

as a revolt against the sovereignty of God and an attempt to be God" (Andrews, 1995). The religious leaders contend that they are not opposing genetic engineering or biotechnology itself, but rather the patenting of human genes or organisms which they consider to violate the sanctity of human life and reduce the results of creation to a marketable commodity. Biotechnology companies respond that patenting is essential to their ability to raise the capital necessary to develop the technology. Since biotechnology companies need to spend tens of millions of dollars before they have a marketable product, they contend that patents are needed to provide the assurance of being able to profit in the event that the high-risk research is successful. A biotechnology spokesman responded that, "The motivation of biotechnology is not to play God. It is to play doctor. Doing that requires that we learn about, and harness, the genes that God has placed in us, and to fix any that, through an error of nature, are not working properly".

An interesting question is why information technology, with its much wider and more intrusive impact on human behaviour (see section 2.9), has attracted so little criticism compared with the much less-developed biotechnology. One reason for this contrast may be that people appear to pay only lip service to the values which information technology may compromise, such as privacy or freedom from social control, but are truly worried when biotechnology appears to pose health risks and, most important, impinges on moral and religious agendas.

While the technology-led information economy is leading to greater automation, on balance it does not seem to save people much time or significantly raise their living standards (Kuttner, 1995). Neo-Malthusians might contend that much of the innovation seems to be more trouble than it is worth, and does not really contribute to productivity in any measurable way. With the post-industrial economies increasingly focusing on services which include jobs that do not evolve with technology, much of the perceived "progress" is in fact illusory. Kuttner (1995), for example, concludes that the

new information technology produces almost as many costs to productivity as it does benefits, and the rapid evolution of the technology means increasing amounts of time spent learning how to manipulate the new generation of equipment. Thus the information economy may be innovating at a rate that is faster than optimal -- faster than people are able to learn how to use the new tools. And don't forget that nobody has matched Shakespeare for quality and output, and he used a quill.

And the benefits of other forms of technology are also accompanied by costs. Garrett (1994) contends that many recent scientific and social developments have actually worked to amplify the range and virulence of dangerous microbes. The widespread use of antibiotics and other drugs has led to a host of mutant strains of microbes, resistant to all or most treatment, including penicillin-resistant staphylococcus, antibiotic-resistant pneumonococcus, strains of malaria which are resistant to most drugs, and strains of tuberculosis which are resistant to most drugs currently used in treatment. The use of DDT to control malaria-carrying mosquitoes has similarly backfired, leading to declining diversity in the insect world and the eventual resurgence and spread of disease-bearing mosquitoes.

And while technology is surging ahead, many developing countries have lapsed into an under-class that cannot apply science and technology to meet the basic needs of their people or to enhance the efficiency of their domestic production and services to compete in world markets. One danger is that some of the new technologies may in fact harm the developing countries by making redundant certain economic activities. Clearly, economic change and technological development are seldom beneficial to all; a change is likely to benefit those groups or nations that are best able to take advantage of the newer methods, and will damage those who are less prepared technologically, culturally, and politically to respond to change. The danger that the world will become further split into technology-rich and technology-poor is one that must be of great concern to conservationists. Technology is not culture-free and

carries with it unpredictable implications for humanity, and for our relation with the environment.

TECHNOLOGY: PREDICTIONS

By 2025, transgenic organisms will routinely be released into the environment. Genetic engineering will enable plants to react rapidly to environmental signals so that crop yields will be less affected by changing environmental influences such as rainfall. Many fruits and vegetables will be genetically engineered to control the rate of ripening, leading to new sources of income for developing countries resulting from post-harvest stability, thereby increasing the amount and diversity available for export. Thus post-harvest losses due to spoilage will be dramatically reduced and delivery of food may represent an important opportunity to enable many developing countries to become self-sufficient in food production.

Plant molecular and cellular biology and related biotechnologies will be combined with traditional breeding to contribute significantly to the development of agriculture, leading to a second "Green Revolution". Genes will be identified and transferred to confer increased resistance to fungal, bacterial, and viral diseases, attack by insects, and competition by weeds, and enable crops to adjust to climatic stresses as well. Gene transfers will enable plants to synthesize useful lipids, carbohydrates, and biodegradable plastics, as well as pharmaceutical products. However, biotechnology will need to adapt to the possible reduction of raw materials (i.e., genetic variation) brought about at least partly by biotechnology.

Superconductors, which carry current with essentially no resistance, will lead to dramatic technological breakthroughs. New substances also will be developed, such as steel-titanium alloys and graphite and epoxy composites that will enable supersonic jets to cover the skies. Scientists will finally begin to unlock the secrets of biological materials such as spider silk, abalone shells, and chitin (a main ingredient of insect cells). "Having spent this century improving on nature", **Time** magazine suggests, "engineers may be spending the next 100 years letting nature improve on technology".

Hydrogen fuel cells are being developed as an alternative to petroleum-based fuels for automobiles, and current expectations are that hydrogen-powered cars could be on the road within the next decade or so. Fossil fuels and accompanying pollution will be replaced by new problems.

Industry in the industrialized world will have moved over to the use of industrial robots in a very big way, with resultant increases in efficiency and productivity (vast unheated and unlit buildings crammed with machines operating 24 hours per day, 7 days per week with just occasional visits from inspectors and maintenance teams). Most employment in the these countries will be in the services sector, with "productivity" becoming ever more abstract.

The split between technology-rich and technology-poor countries will continue to grow, and many of the most technologically qualified individuals from the developing countries will emigrate to the technology-rich countries where they perceive greater opportunities. As the developing countries develop their own appropriate technology, some of the brain drain will reverse as indigenous forms of technology become more adaptive to local social, cultural, and economic needs.

Kennedy (1993) considers that the "most important influence on a nation's responsiveness to change probably is its social attitudes, religious beliefs, and culture. Students of past civilizations that failed to adjust to the challenge of modernization point, in example after example, to the obstacles which hindered new developments: a distaste for industry and manufacture, a mandarin suspicion of trade and enterprise, an ideological or religious opposition to western, capitalist mores, power structures which favoured courtiers, the bureaucracy, the military, and the church, and legal and taxation systems (or even outright plunder) that discriminated against entrepreneurs and in favour of office holders". On the other hand, where merchants and entrepreneurs are encouraged, where no rigid, doctrinal orthodoxy constrains adaptation, where freedom to enquire, dispute, and experiment are encouraged, where people believe in the possibilities of improvement, where people are concerned more for the practical than the abstract, where rationalism defies mandarin codes, religious dogma, and traditional folklore, countries are far more likely to be able to take advantage of the technological changes that are likely to come. Whether that is a good thing in the long run is a moot point.

Optimists will point to a growing trend toward appropriate technology, that which draws on the needs and capacities of local people and ensures that modern technology is adapted to the local needs (Swaminathan, 1995).

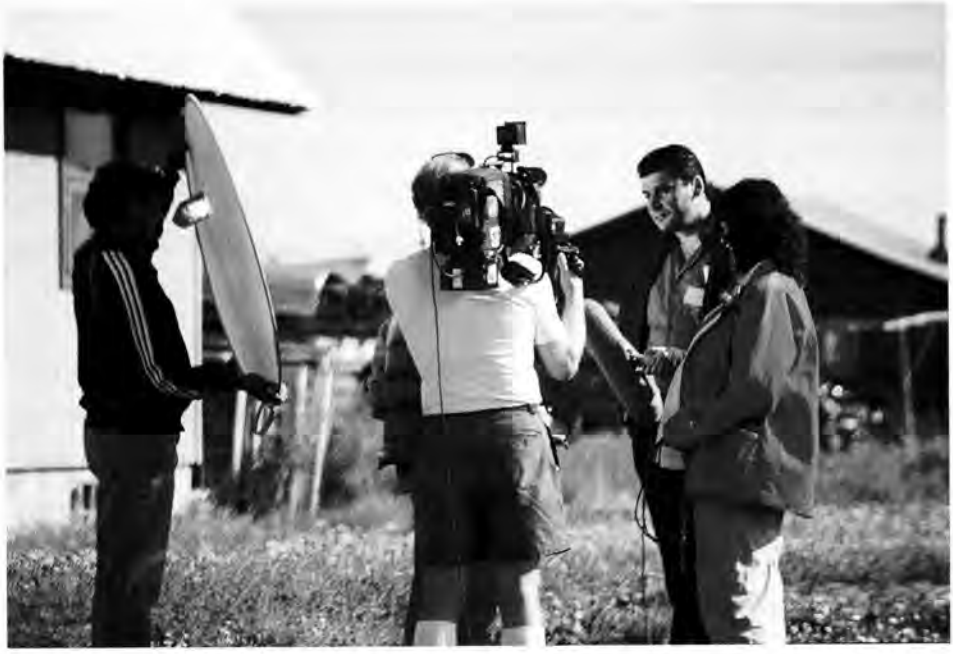
2.9. Changes in Information and Communications

Conservation has been a social movement, and like most social movements is led by information. But social movements must continue to evolve or they recede in importance. We should certainly celebrate our successes, such as the broad public awareness of endangered species (at least in developed countries), the hundreds of millions of visitors to protected areas, the continuing expansion of the global protected area estate, the greening of many governments (at least in their public statements), and various other conservation measures. But ironically, good news does not sell nearly as well as bad news, forcing conservationists to focus on bad news and alarming predictions. The disadvantage to this approach is that when advocates cling to their rhetorical palisades, their positions become more rigid, leading critics to become more exasperated. Exaggerations on one side can inspire absurd reactions on the other as debate becomes more shrill and politics grow more polarized, making compromise and informed decision-making more difficult rather than more likely. A new form of rhetoric needs to be considered in order to fight the inevitable backlash from our successes (however modest they may have been).

The global marketplace and global access to mass media hungry for controversial stories underlines the vulnerability of international organizations to pressure from environmental organizations such as Greenpeace, which recently hit headlines over the de-commissioning of the Brent Spar floating oil platform owned by Shell and the French decision to resume nuclear testing in Polynesia. The position of Greenpeace in both cases was based on ethical issues, not scientific ones. This certainly is fair enough, and it is clear that Greenpeace is at heart an ethical movement which strikes a responsive chord in

the hearts of many of the world's people. But it certainly is not science-based. The danger is that advocates often must play fast and loose with science; and the same science can support diametrically-opposed positions.

The technology of communications also carries dangers, the pessimist might warn. Slouka (1995) foresees a sinister new world in which telecommunications replaces physical contact and meaningless abstractions replace a sense of community and place: a world where people are concerned only with themselves and become easily subject to manipulation by charismatic ideologues. As we all know, electronic documents are subject to change in all sorts of ways, establishing impermanence as the norm. The relationship among the mass information media and politics is emerging as a central problem, and it is becoming increasingly difficult to tell who the real power brokers are -- the politicians or the media barons.



Information is power, and the new information technology is empowering people in all parts of the globe. On the other hand, the capacity to control information is also growing.

Information is being controlled by fewer and fewer multi-national corporations, as indicated by the recent acquisition of ABC by Walt Disney, Westinghouse Electric's acquisition of CBS, Time-Warner's flirtation with CNN, and Star TV's expansion from India to cover Asian markets from Dubai to Indonesia, giving all a greatly-expanded global reach. Such acquisitions are expected to have a profound influence on shaping the television news industry. Clearly, the trend is more toward entertainment than information. The recent mergers have tended to drastically reduce the relative importance of the news departments, so an already-diluted pool from which the values of journalism will be drawn has been reduced to peripheral importance in corporate decisions. "Truth" may become increasingly abstract and subject to manipulation by special interests.

Information undoubtedly will be one of the most valuable commodities of the future, but information technology tends to make at least some information freely available, which may diminish its value and its quality. Furthermore, information is increasing very rapidly, perhaps too rapidly to apply wisdom and reflection to the overwhelming flood of new data. This has been likened to "trying to get a drink from a fire hose," and is forcing the political system to become more sensitive to the transitory priorities of a public manipulated by the mass media (leading to what some observers consider a mal-adaptive "hyper-democracy").

On the other hand, optimists might contend that global communications can make information far more democratic. For all parts of the world, information and communications technology (ICT) can be a path to greater freedom. Information is power and ICT can empower people by organizing, storing, retrieving, sharing and disseminating information. Computer hardware, software and electronic communications help ensure informed decision-making, make it easier to evaluate and compare options and scenarios, and allow speedy identification of experts, organizations and resources. During the 1980s and 1990s, ICT has helped to make possible an extraordinary increase in

peer-to-peer communication, challenging traditional concepts of hierarchically-structured organizations and leading to the emergence of flattened structures that are based on "peer acceptance" rather than "mandate". Optimists hope for a twenty-first century world of information-based cooperatives rather than twentieth century "ivory towers" or fortress-like organizations holding exclusive "mandates".

While some parts of the world (especially Africa) are lagging far behind the vanguard of the communications revolution, Internet already has more than 50,000 interconnected computer networks, enabling people in different countries to communicate whenever they wish. The population on the Internet is now increasing at about 10 percent per month, a rate of growth that would lead to the total number of Internet users exceeding the world population by the year 2003 (though of course the growth rate is likely to soon decline as the market becomes increasingly saturated).

The evolution of conservation organizations toward decentralized and regionalized ways of working is very much about creating environmental cooperatives based on "peer acceptance". But to function effectively, these cooperatives will require more than commitment, information, expertise, strategic planning and priority-setting. They will require information and communications technology. ICT offers cost-effective tools for building the "infrastructure and highways" that extend connections, interaction and exchange as widely as possible. The success of people-led cooperatives will depend on making best possible use of this technology in pursuit of carefully planned and clearly defined goals.

The impact of ICT on international conservation organizations will be profound. Their organizational identity, structure and operation will no longer be constrained by distance and geographical location but will become global and immediate through our use of the world's multi-media Global Information Infrastructure. Staff will not necessarily "go to the office", nor will they have a precise "duty station" or specific hours of work. What is certain, however, is

that they will be able to share more information with more people in more places with greater frequency and at less cost than can be imagined today. But ICT will also be used by those seeking to promote greater consumption of resources, and fight against the perceived power of environmentalists; a major challenge will be to use ICT to promote more effective conservation in the face of continued pressure to promote more consumption.

CHANGES IN INFORMATION AND COMMUNICATIONS: PREDICTIONS

To establish successful claims to resources, nations and communities will need more and better information, so investment in research will increase to support the continuous quest for knowledge and greater understanding of environmental issues.

Advances in telecommunications will enable people to communicate quickly with anyone anywhere in the world. Portable telephones that will enable people to communicate from the most remote parts of the world will be widely available, with communications dominated by a small handful of international consortia which provide around-the-world phone services. It will be possible to give everyone anywhere a super-fast connection to any kind of information, from movies to books, from news to business and shopping data.

A study done for the World Bank predicts a global tele-economy by 2005, which will be based on near-zero-tariff communications. The price of telecommunications will be based on higher added value services rather than traditional profit from the sale of a basic connection. In short, telecommunications will become a right rather than a luxury.

Information flows will become more self-managing and information communities will develop around issues of a quite specific nature; such networks will shift and flow as needs change, but centralized databases will be in less demand and large, slow organizations will be unable to compete. The emphasis will shift to development and application of standards and guidelines to promote information management and its application to real environmental problems. The bottom line is that many solutions to developing country problems exist, but the application of these solutions is often inefficient and inadequate; and many development projects often seem to serve to perpetuate the status of developing countries rather than bring them up to competitive positions relative to the developed countries (Buttel, et al., 1990; Forje, 1989; IDRC, 1990; Makau and Aduwo, 1989; Sanchez and Juma, 1994; and Swaminathan, 1982).

Clearly, the developing countries are all very different, and some are well able to take advantage of the changing conditions in communications as the 20th century comes to a close. The extent to which the more successful developing countries wish to assist the others remains to be seen.

Virtual reality -- creating an artificial environment so convincing it cannot be distinguished from the real thing -- will be widely available for a range of applications, from entertainment to design to tourism; people will be able to take utterly realistic virtual vacations to almost anywhere, without ever having to leave the comfort of their own homes. "Couch potatoes" will proliferate.

2.10. Changes in Biological Diversity

The changes described in sections 2.1-2.9 will all have impacts on biological diversity. A consensus of leading scientists has concluded in the **Global Biodiversity Assessment** (GBA) (UNEP, 1995) that the scale of human impacts on biodiversity is increasing dramatically, threatening the very foundation of sustainable development. The rate at which humans are altering the environment, the extent of those alterations, and their consequences for the distribution and abundance of species, ecological systems, and genetic variability are unprecedented in human history, and pose substantial threats to both sustainable development and the quality of life.

Humans have already greatly modified the earth's surface. Ecosystems that have been substantially transformed, managed, and utilized constitute about half the land surface of the ice-free earth, and no truly pristine areas remain. Moreover, the rate of global land use and land cover change is accelerating. Conversion to cropland contributes to much of this land cover change; half of the area of cropland worldwide was added during the past 90 years, with croplands in the tropics doubling in area in the last 50 years. Rates of forest loss in the tropics are currently increasing by an estimated 4 to 9 percent annually (Houghton, 1994).

Although land use change outside the tropics has been relatively small in recent decades (the major periods of profound habitat alteration took place in Europe in the Neolithic and the Middle Ages and in 1500-1900 in North America -- Simmons, 1993), changes in characteristics other than area continue to occur, including loss of biomass and carbon storage (Houghton, 1994; Ojima *et al.,* 1994); the loss of old-growth forest remains a major concern in many temperate countries. Habitat disturbance and other anthropogenic factors may also contribute to species invasions or successful introductions of exotic species. The addition of species may have wide-ranging effects on community composition and dynamics, and alter productivity, soil structure, nutrient cycling and water chemistry. A recent report by the US National Biological Service says that "If unchecked, human activities will continue to result in an upset balance of species interactions, alteration of ecosystems and extensive habitat loss". Even an environmental optimist such as Easterbrook (1995) recognizes that preservation of natural habitat "is likely to be the primary ecological issue of the coming century".

The GBA concludes that the world is already committed to further species extinctions and the loss of populations and genetic resources, even if responsible actions were taken immediately. According to IUCN figures, since 1600 at least 484 animal and 654 plant species have gone extinct (IUCN, 1994). Based on historical records that span the past four centuries, the extinction rate for vertebrates and plants is estimated to be 50 to 100 times the expected natural rate. When fossil records that date back 2,000 years are used, the estimated rate for bird extinctions ranges from 500 to 1000 times that expected. Finally, when projections of future extinction rates are based on habitat destruction and empirical studies of habitat-area relationships, the estimated rate exceeds that expected by substantially more than 1000 times. For some groups of vertebrates and plants, between 5 and 25 percent of the identified species are already listed as being threatened with extinction (IUCN, 1994). Although many areas of apparently natural vegetation remain, large animals on which many plant species are ecologically dependent may have

been hunted out by humans (Redford, 1992). The result may well be the profound change of these areas, with the new ecosystems being much less useful to people though not necessarily less complex ecologically.

Habitat loss, modification and fragmentation are widely considered the most important cause of loss of biological diversity, with most current attempts to estimate and project the rate of species loss based on reductions in habitat area (WCMC, 1992). Recent work (Tilman *et al.,* 1994) has documented an "extinction debt" associated with habitat destruction, in which the rate of extinction increases as a function of the area of habitat that has already been destroyed. For instance, destruction of an additional one percent of habitat causes the extinction of 8 times more species if 90 percent versus 20 percent of a region has already been destroyed. Furthermore, an unanticipated effect of this habitat destruction may be the selective extinction of the best competitors -- those species that are often the most efficient users of resources and major controllers of ecosystem functions. Thus, this extinction debt may have dramatic effects on the ecosystems of the future and the ability of these ecosystems to deliver vital services to human populations.

The opposite trend -- bringing in new species -- is also dangerous. A crucial element in the changing biological diversity of most ecosystems as a result of increasing global trade is the introduction of invasive exotic species. While such invasions often mean that any particular site has greater biological diversity now than formerly (England, for example, now has more species of deer than at any previous time in its history and New Zealand has more than twice as many plants), the overall impact of these invasive species is unknown.

Not only will land areas continue to be affected, but so too will marine and freshwater areas. Marine ecosystems are increasingly affected by logging of forests and mangroves, siltation, dredging and channelization, pollution, shoreline development, oil and gas development and other human modifications, as well as introduction of exotic species and offtake of fish and other marine species (both deliberate and incidental) (Norse, 1993). And

freshwater fish are the vertebrate group that has suffered the highest extinction rates, in both tropical and temperate regions.

These alarming trends have forced natural scientists to give renewed attention to the role of change in ecological systems. The emerging modern view, sometimes called the "flux of nature" or "non-equilibrium" paradigm, emphasizes process rather than endpoint, in contrast to the previous "balance of nature" or "equilibrium" paradigm. The flux of nature acknowledges constant change, contending that natural communities have multiple stable states (Pickett *et al.*, 1992; Holling, 1992).

Change constantly occurs on an infinite number of spatial scales -- from tree falls to the impacts of meteors -- and temporal scales -- from continental drift to sunrise and sunset (Holling, 1986). Variability and instability are the traits necessary to retain the resilience of ecosystems, or their ability to adapt to disturbance through rapid shifts to alternate stable states or through evolutionary organizational change. An important implication of this view is that reductions in natural variability lead to fragility and lessen the likelihood that disturbance will bring about a transition to an alternate equilibrium. Condit *et al.* (1992) concluded that all biotic communities undergo constant flux as populations or individual species expand, contract, go extinct locally and remigrate in response to local ecological and evolutionary change and other major changes from outside the system (such as climate change).

Arrow *et al.* (1995) suggest that the loss of ecosystem resilience through reductions in biodiversity could have three profound consequences:

- √ discontinuous change in ecosystem functions as the system flips from one equilibrium to another could be associated with a sudden loss of biological productivity, and thereby reduce the capacity of ecosystems to support human life;

All indications are that biodiversity is being lost at a global scale, though human activities may increase, maintain, or diminish the diversity of genes, species, or ecological communities at the local level.

√ the loss of resilience may imply an irreversible change in the set of options available to humans (for example, through soil erosion, depletion of ground water reservoirs, desertification, and loss of biodiversity);

√ discontinuous and irreversible changes from familiar to unfamiliar states increases uncertainties associated with the environmental effects of human activities.

Botkin (1990) characterizes nature's harmony as discordant, made up of a combination of many simultaneous and dynamic processes, leading to a symphony that is sometimes harsh and sometimes pleasing. While change and disturbance are essential features of ecosystems, the world view presented by Botkin views complex systems as dependent for their survival on connectivity and interdependence among their parts, and on feedbacks among related

processes. It stresses that emergent properties, characteristics of the whole rather than of the individual parts, are the most important features. This focus on the complex interactions and complete systems leads to policies that concentrate more on partnership, and on understanding and building motivational structures to achieve desired ends. Thus human nature is an element to be factored into the equation, not to be "conquered" (Sahl and Bernstein, 1995). Such a view also underlines the importance of uncertainty and change, thus fostering risk management and prudence rather than futile attempts to remove risk entirely.

To conclude this brief discussion of biodiversity, depending on the circumstances, human activities may increase, maintain, or diminish the diversity of genes, species, or ecological communities in a given region and at a given time, but the general trend is an increasing loss of biodiversity at the global scale, a net gain in biodiversity at some locations as introduced species outnumber species extinctions and new communities are formed, and increasing human impacts on "natural" ecosystems. Some of these changes are irreversible, such as extinction of species. Other changes are more cyclical, but all present challenges in managing natural resources in a sustainable manner without losing the diversity which will enable the system concerned to adapt to change. The Convention on Biological Diversity, CITES, the Migratory Species Convention, the Ramsar Convention, and the Law of the Sea will provide international fora where the issues of biodiversity will continue to be debated. The effectiveness of these fora will depend very much on the willingness of governments to use them, and this in turn will depend especially on public perceptions of the importance of biodiversity to a changing world.

BIODIVERSITY: PREDICTIONS

Pressure on wild resources will increase dramatically, leading either to reasonably-controlled harvesting or loss of the resource. At the institutional level, decentralized management of nature by rural communities will become increasingly important. The relative decline of central governments sets the stage for developing a coalition of local actors, with partnerships among a range of organizations. However, disintegration of public authority and accompanying insecurity in some areas may lead to extreme degradation of resources.

Understanding of the causes and consequences of extinction will increase as knowledge about the organisms and environments increases, changing the way we think about the conservation and maintenance of species.

If current rates of loss of closed tropical forest (about one percent globally per year) continues for the next 30 years, the number of species these habitats support will be reduced by 5 to 10 percent, as new equilibria are reached between the size of habitat and the number of species that can be supported. However, most evidence indicates that "equilibrium" is primarily a theoretical concept, and instead most ecosystems will be expected to undergo constant change.

A complete database of all known living organisms, including taxonomic, morphological, ecological, biogeographical, and biological data, will have been established; and a complete census of species ("all-taxa inventory") in selected habitats will be made. With improving computers and databases, coupled with enhanced capabilities of remote sensing, ecologists will be able to study phenomena on large spatial and long temporal scales. Current and future conditions will be understood to depend on history as well as on observable processes such as dispersal, competition, and predation. The global phenomena of environmental change and habitat destruction will be

integrated with the historical record, increasing our ability to understand the consequences of environmental change and the role of humans in these changes. Will improved understanding lead to more enlightenment?

Rare or particularly valuable individual plants and animals will be implanted with micro-chips containing their vital statistics and helping to control illicit trade. In South Africa, cycads have already been bugged in this way, and a satellite tracking system is used to keep track of them.

Protected area systems will continue to evolve in most countries, as some areas are converted to agriculture or other non-conservation purposes, only to be replaced by land currently used for forestry or other purposes. In many countries, protected areas will be managed increasingly by a wide range of different kinds of institutions, including private land owners, non-governmental organizations, and even private sector institutions such as tourist agencies. Multiple-use management protected areas (such as IUCN Category VI protected areas and biosphere reserves) will become increasingly important.

Capture fisheries will become increasingly less important, as many species of fish in previously rich fishing areas will become commercially extinct. The estimated maximum sustainable capture fishery production of 100 million metric tons will be surpassed by demand for fish and fish products amounting to 135-165 million metric tons early in the next century. Aquaculture increasingly will replace capture fisheries and some fish species will be domesticated; the diversity of fish used by people will decline significantly.

3. ADAPTING TO CHANGE

As discussed above, human populations have already exerted fundamental influences on biological diversity and the earth's capacity to support and maintain such diversity. It appears inevitable that changes already wrought will bring further losses of biodiversity in the future, though many localities will in fact enjoy greater species diversity due to introduced species. However, change is also integral to human populations, and in turn changes are often a response to shifts in biotic and abiotic systems. This section will assess current viewpoints on the ability of individuals, institutions and societies to evolve and adapt in response to the changes already underway in natural systems. Conservation organizations can help to guide and support these adaptations to changing conditions, if they establish the means for doing so.

The 1980 **World Conservation Strategy** heightened awareness of the ecological impacts of economic development, and of their increasing severity. However, it is also increasingly recognized that environmental change is not only a consequence of affluence; it is also a cause and effect of poverty (WCED, 1987). Malthusian forecasts indeed often present a scenario in which ecological collapse hits the poor first and hardest, causing famine and disease in developing countries on a scale surpassing anything yet experienced by the human species. In an era of global ecological and economic integration, the impacts of the crisis will be felt worldwide, inevitably affecting industrialized countries as well (e.g., Kaplan, 1994). This is nothing new; the ancient Greek philosopher Plato (c. 429-347 B.C.) argued that the two elements leading to the demise of a "moral and good" society are poverty and affluence.

Optimistic forecasts typically begin with a recognition that the needs of the developing world are tremendous, and those needs must be met, for humanitarian even more than for political reasons (e.g., MacNeill *et al.,* 1991; IUCN, WWF, and UNEP, 1991). It is therefore clear to the optimistic that continuing development will be necessary to meet the basic needs of present and future human populations. Several possible mechanisms are proposed for averting global crisis, including continued technological development in response to growing population and resource constraints, sacrifice of future growth in consumption on the part of wealthy nations in order to allow future growth in the developing world (Goodland *et al.,* 1991), or direct transfers of resources and technology to developing countries (Pearl, 1989). However, current trends in development assistance call into question whether appropriate changes can and will be made in the policies and institutions that will determine patterns of growth and development.

This section will discuss how humanity can adapt to change, and identify -- in at least a preliminary way -- some of the constraints to adapting to change.

3.1. Problems of the Distribution of Benefits from Development

While the industrialized countries are spending billions of dollars for marginal environmental improvements especially in the field of pollution, developing countries face immediate and obvious health threats from diseases associated with poor sanitation, polluted drinking water, and other environmental ills. Funds spent to address these developing country problems -- following the example of carbon off-sets -- would be far more efficient in addressing global environmental problems.

Technological solutions are also limited by their uneven availability. Not only is access to resources and skills unevenly distributed in the present, but the costs of new technology are likely to be prohibitive for many developing countries, so that future development is likely to preserve the existing

international economic structure for decades to come (Theys, 1987). The first products of biotechnology research, for example, are just becoming available after 20 years of research, but research and development are concentrated in industrialized nations. Further, much of the work in this area is directed toward high-value crops cultivated in developed nations, rather than the subsistence crops of tremendous importance to the developing world; or for medicines which treat the ills of industrial society rather than the far more common maladies of the poor. Many of the products of agricultural biotechnology are likely to compete with tropical export commodities, such as palm oil, rubber, and cocoa, further weakening the position of developing countries in international markets (WRI, 1994).

The developed world is also much more likely to successfully absorb the economic costs associated with global climate change, and to have access to the benefits of biotechnology and other technologies that will allow high standards of living to be sustained. Although few studies have compared human responses to climate change in developed and developing countries, Mooney *et al.* (1993) point out that high incomes in North America will facilitate mobility and adaptation in response to global change. By contrast, Fuentes and Muñoz (1993) hypothesize that climate change will force small-scale Chilean agriculturalists to intensify agricultural production on steep slopes and increase secondary activities such as logging and mining, thus intensifying the environmental impact of current land use practices. Indeed, they expect land use and cover change to outweigh the effects of climate change in South America. Low-income agricultural households in the developing world will be particularly vulnerable to the increasing frequency of extreme climatic events as well as temperature change, although forecasting of the effects on agricultural production has primarily been conducted in developed countries (Parry and Jiachen, 1991).

Thrupp (1995) has pointed out that the export of non-traditional crops such as fruits, vegetables and flowers flown to North America from Latin America and the Caribbean have increased by 17.2 percent a year between 1985 and 1992,

and by 48 percent in South America (excluding Brazil). During the same period, Ecuadorian flower exports grew 15-fold in volume and 30-fold in value. Because many of these crops are labour-intensive, expanding production has generated hundreds of thousands of jobs, especially for women. In Colombia, for example, the flower export industry employs about 80,000 workers, 80 percent of whom are women. One downside is that these crops use far more pesticides than traditional crops, leading to considerable health problems. Further, the benefits of these new crops tend to be concentrated in the hands of wealthy investors and foreign distributors; while many of these crops can be grown on small plots of land, most are grown by industrial farmers who have better access to credit, technology, and information. Further, economic uncertainties cloud the outlook for these new crops. Prices are highly volatile, inputs are costly, market requirements are demanding, competition is fierce, and the export windows are narrow.

Thus the benefits of development often flow primarily to those who are already relatively well-off, leaving the marginal farmers often further marginalized onto lands which would be far more appropriately devoted to agro-forestry, extensive grazing, or biodiversity protection. This is a recipe for continued environmental degradation and even violence (e.g., Myers, 1993).

3.2. Prices, Politics and Alternative Models of Development

The problem of scientific uncertainty is nearly universal in the development of appropriate economic and environmental policy. The complexity and natural variability of biological and physical systems mean that levels of resource exploitation must be set by trial and error, with over-exploitation often not detectable until it is severe or even irreversible (Ludwig *et al.*, 1993). Scientific consensus on the impacts of exploitation is seldom achieved, even after the resource has collapsed. Furthermore, even when considerable scientific evidence exists that a given practice or technology will prove ecologically destructive, this degree of certainty has not proved sufficient to prevent the

unsustainable use of resources. "Resource problems are not really environmental problems: They are human problems that we have created at many times and in many places, under a variety of political, social and economic systems" (Ludwig *et al.,* 1993). Resource problems are often due to simple greed and the lack of political will to control it (indeed, in some countries, the politicians are leaders of the greed brigade).

The development of appropriate economic and environmental policies to deal with biodiversity problems is thus hindered not only by problems of scientific certitude, but also by lack of understanding of the driving forces underlying individual and collective human behaviour and the relationships among human behaviour and global change. For example, only relatively recently has a body of evidence emerged on land use and land cover change that attempts to identify the social, economic and political forces that determine land use patterns, and the understanding of relationships between land use and global environmental change (Ojima *et al.,* 1994). One of the contributions of this multidisciplinary research is the recognition that the fundamental causes of land use and land cover change may originate far from the ecosystem, or even region, affected. Regional and local responses to these causes vary widely depending on available resources and on local political, social and economic conditions. Further research is needed to determine local and regional variations in the human dynamics of global change (Kummer and Turner, 1994; Skole *et al.,* 1994; Collier *et al.,* 1994).

One of the problems that this raises for appropriate environmental policy is "scale mismatch", in which human responsibility does not match the spatial, temporal or functional scale of natural phenomena (Lee, 1993). Adjustment of short-term, specialized human behaviours to account for their broader long-term ecological consequences depends in part on improved understanding of those consequences, but ultimately depends on politics (Holdgate, 1991) -- developing the institutions, management styles, and policies that link individuals with their impacts on the global environment. Another growing body of research focuses on the development of diverse and context-specific

institutional arrangements that correct such mismatches of scale and reduce the human conflicts they produce (Ostrom, 1990; Bromley *et al.*, 1992; Haas *et al.*, 1993).

If history is any judge, we can expect the next few decades to see many different approaches to development, including those led by eco-feminists, various forms of eco-development, hyper-industrialization, and a wide range of other options. Many of these will be far more sensitive to the needs of local communities than is the current global marketplace model (Western and Wright, 1994).

3.3. Building the Capacity to Adapt to Change

In the short term, policy-makers may be forced to respond to calls to limit human impacts on the earth in ways suggested by the best available information and technology, even in the absence of consensus on the way human and natural systems work. Given the scale of expected human-induced global change and the limitations of natural and social science in predicting the future, some observers suggest that the major challenge in decades to come will be to adjust to the unexpected (Theys, 1989). Planning methods for the uncertain and the unexpected involve adjusting the values for which ecosystems are managed, and adjusting the management styles adopted to achieve those values.

Successful human adaptation to global change may depend on managing human impacts on ecosystems for the values of variability and resiliency, rather than for predictability, as has been the trend in the past. The maintenance of biological and cultural diversity is itself an important contributor to variability and resiliency, and many of the methods proposed for biodiversity conservation have important implications for global change. Walker (1989) suggests, for example, that protected areas should maintain the elements of heterogeneity and variability that allow for change. Efforts to

stabilize an ecosystem or to preserve an individual plant or animal species may be counterproductive, he contends, since these efforts may disrupt the ecosystem processes that are the most critical value in conservation; this may require conservation organizations to increase their activities in the field of species conservation policy. Ryan (1992) applies this concept to intensively-managed systems as well, noting that diversification of products and production methods within a management area also improve the capacity to adapt to change.

Planning for the uncertain and the unexpected can best be achieved by adopting a management style that is flexible, adaptive and experimental (Holling, 1986). Political decisions typically involve quick fixes for quick solutions, designed to maintain an imperfectly understood system in a constant state. The result is greater ecosystem fragility and higher stakes for future policy and management. The alternative of adaptive management is designed explicitly for decision-making in the face of uncertainty.

The principles of adaptive management may be described as follows: "consider a variety of plausible hypotheses about the world; consider a variety of possible strategies; favour actions that are robust to uncertainties; hedge; favour actions that are informative; probe and experiment; monitor results; update assessments and modify policy accordingly; and favour actions that are reversible" (Ludwig *et al.,* 1993). To this list one might add: "build feedback into all management systems; use a variety of sciences and ways of knowing; and maximize cultural and biological diversity". Holling (1994) suggests a number of strategies for experimentation in short-term change variables and monitoring of long-term shifts in ecosystem processes; experimentation and monitoring that combine perspectives from both the natural and social sciences may contribute greatly to our understanding of the human impact on global ecosystems.

Democratic systems tend to be more self-corrective and thus more resilient, but also seem less willing to take tough decisions. More adaptive management

styles may also imply greater democracy, or greater use of the human resources we have. Such management systems have one especially interesting paradox: in human organizations, if you want more power, give it away. Managers too often try to centralize to increase power, and this reduces the capacity to use the distinctively human capacities that reside in their workforce.

Social and institutional learning is often an extremely slow process, and the scale and pace of change in global biodiversity are increasing rapidly. However, the possibility also exists for rapid change in human behaviour. For example, smokeless fuel regulations were quickly adopted in response to killer smogs in London in the 1950s, and strong energy conservation measures were promptěd in many countries by the oil crisis of the 1970s (Western, 1989). More recently, abrupt shifts in management policies in response to ecological crises are being seen in a number of settings, from North America to the Baltic Sea. Thailand and China reduced fertility in 20 years that took western societies two generations, and those rapid fertility declines improved maternal and child health. Remarkably, this also happened among those parts of the population -- poor rural women and children -- who are usually the last to benefit from any development activity. Thus while the unexpected may characterize the future, precedents for rapid leaps in the evolution of human capacity to modify human impacts on global ecosystems provide hope for the future.

4. TAKING IUCN INTO THE 21ST CENTURY

4.1. The Current Approaches

This study has discussed some of the changes that will affect conservation in the coming several decades. But what are the implications for IUCN? IUCN has been constantly evolving ever since its birth in 1948. The 1980 publication of the **World Conservation Strategy** marked an important turning point, but it was built on a long series of scientific contributions which justified linking conservation more closely with other human concerns. The partnership of IUCN with development aid agencies through the 1980s was an adaptive response to a greater willingness on the part of governments to invest in conservation-related fields, a willingness driven at least partly by increasing public support for environmental issues which in turn was driven by the efforts of IUCN members throughout the world.

But through all of these changes, the general orientation of IUCN has remained remarkably constant. IUCN has found these major approaches to be effective:

- √ monitoring and assessing what biological diversity exists, under what conditions; identifying the threats to its conservation; and developing an enhanced capacity to define priorities for conservation action;
- √ understanding how species and ecosystems function, how they might be sustained by conservation practice, and how to ensure that any use of wild living resources for human benefit is sustainable;

- √ developing and testing methods for the conservation and adaptive management of species and ecosystems;
- √ identifying and analyzing how human behaviour, value systems, knowledge systems, social policy, development approaches and economic activities relate to the above functions and actions;
- √ understanding how these relationships may affect conservation, ecologically sustainable use and equitable access to natural resources;
- √ assessing what policies, changes in behaviour, management approaches, social organization, legal frameworks and international agreements are necessary to implement sustainable forms of development which recognize these relationships;
- √ where damaging impacts do occur, assessing what adjustments are necessary and what tools (processes, policies, methods, instruments) are most effective to correct or compensate for those impacts;
- √ promoting the training and education of conservationists at all levels, and encouraging their involvement with local communities worldwide in the development of sustainable ways of living;
- √ communicating the work of the Union and advocating its agreed policies directly and via media and interpretative systems, so as to influence the way societies relate to living resources.

IUCN has always focused on renewable natural resources, but the specific activities IUCN undertakes in a country or region will vary because the threats and opportunities facing the resources also vary. For example, in eastern Europe, pollution is the main threat and must be taken as the point of departure. The problems in the Sahel are due to drought, population growth, outdated production techniques, and inappropriate land tenure arrangements, requiring IUCN to work with production systems, migration problems. land

tenure problems, and so forth; but many of these problems are also the result of policies of the European Union, requiring IUCN to be active in Brussels and Strasbourg as well. In many tropical rainforest countries, over-exploitation of the forest is the main issue, leading IUCN to focus on sustainable management of these systems. In Latin America, uneven land distribution underlies many of the natural resource problems, so IUCN must have an effective policy on this issue if we want to be a significant contributor to solving conservation problems in that region. These are all adaptations of IUCN's general approach to the specific requirements of a country or region, and IUCN's regional structure must be used to provide continuing flexibility and to adapt to changing conditions.

4.2. Three Pillars for the 21st Century

While IUCN must continue to adapt, the discussions held at the World Conservation Congress in Montreal in October 1996 suggested that the three pillars of its programme in the coming century will sound familiar:

1) **Monitoring of species and ecosystems**. IUCN Members will still need access to information on the status and distribution of biodiversity, whether this is accessed through databases IUCN manages in collaboration with its partners, or through improved information networks. Traditional IUCN products such as Red Data Books and the UN List of National Parks and Protected Areas will still play a valuable role, although the format in which they are produced will have evolved. In the shorter term, new products might include: assessment of the status and distribution of biodiversity; analysis of emerging "ecological hotspots" based on a variety of criteria; analysis of the impact of the brown agenda on conservation; a "Global Green Report" (equivalent to UNDP's Human Development Report); and a series of special reports on key issues of current concern (e.g., any remaining old-growth forests, application

of biotechnology to species recovery, cryopreservation as a conservation technique, etc.); and provision of conservation information to various international bodies, including a new international governance system which includes governments, the private sector, and NGOs as equal partners.

2) **Analysis and dissemination of environmental management policies and instruments.** Focal areas would include environmental economics and finance (e.g., green accounting; incentives; cost-benefit analysis; financing conservation); national planning and policy frameworks (strategies and environmental law); collaborative management systems (i.e. State, communities/NGOs, private sector) for wildlife, the commons, protected areas, forests, etc.; global environmental governance (e.g. trade, conventions, polluter pays principle, development aid and conservation finance, carbon taxes); universal standard setting (e.g. categories for endangered species/protected areas; guidelines for coastal zone management; mining on the moon for helium-3).

3) **Environmental assessment, advisory and mediation services.** Key services would include independent environmental assessments of complex/controversial issues (from dams to ivory trade, if any elephants remain); advisory services to international agreements, including the Environmental Law Service, SSC/CITES work, support to the Convention on Biological Diversity and the wide range of institutional and capacity building services provided through RCOs; a roster of vetted experts and institutions on major environmental issues; and an environmental conflict mediation service addressing conflict prevention, avoidance, resolution and settlement issues based on IUCN's technical competency and credibility.

Nor are the required core competencies much of a surprise. These will include outstanding environmental and scientific expertise (especially in the social and biological sciences); network development and management capacity; the wisdom to transform data into information that will be useful to our members; the capacity to manage expertise and apply it to the highest priority challenges; and skills in environmental policy dialogue and diplomacy.

IUCN will also need to be alert to changes in other institutions, as it must define itself largely by its relationships to these, and to the world at large.

The big issue for IUCN in the future, as in the past, will be its sources of funding, as these determine the direction the Union will take. While we will always insist that we are mission-led and constituency-driven, funding will still be the ultimate driving force as the best indicator of public preferences. As indicated earlier, budgets from development agencies, the UN system, and governments are entering a cyclical decline, so IUCN must again return to its members, and through them the general public and the corporate sector. For the sake of perspective, it should be noted that General Motors and Exxon are both larger in financial terms than Saudi Arabia or Indonesia; so IUCN in its collective wisdom must embrace the corporate sector.

4.3. Some New Directions for the Coming Century

Government resource management agencies, scientific institutions, and non-governmental conservation organizations in developing countries will become increasingly competent in various aspects of conservation, making IUCN technical advice relatively less important and IUCN networking services increasingly more important. By the early 21st century, IUCN should be out of the project management business, instead providing technical support of various sorts to projects that are run by IUCN members; this will provide a stronger framework for cooperation and avoid competition with our members. IUCN roles for the 21st century may include:

- √ serving as a facilitator for forging local alliances for conservation management, and as a scientific witness of the impacts of conflict and over-use of resources;
- √ building partnerships with relevant multinational corporations active in fields of interest to IUCN, including forestry, agriculture, tourism, pharmaceuticals, energy, and others;
- √ maintaining an active population and resources programme, with a focus on the implications for conservation of the changing proportions of rural and urban populations;
- √ collecting information to enable IUCN Members to take a much more active stand against excess consumption in industrialized countries and by elites in the developing countries;
- √ continuing its activities in sustainable use of wildlife, as this issue will be a continuous one of constant re-adaptation requiring policy studies and assessments of the environmental consequences of various options for utilizing living resources;
- √ remaining active in the further development of biodiversity-related international and regional agreements (CITES, Biodiversity, World Heritage, Wetlands, Law of the Sea, etc.);
- √ expanding its activities in determining new and more efficient ways of managing areas important for conservation, including objective examination of alternative management regimes (including by the private sector);
- √ greatly expanding its work on invasive species, working especially with its members who are actively addressing these problems (primarily government agency members);
- √ developing a capacity to promote restoration or rehabilitation of ecosystems, as a way of accelerating their recovery toward a state which people find appropriate and attractive.

- √ supporting the views and interests of local communities (including those groups who consider themselves "indigenous people");
- √ examining the relationship between the global marketplace and cultural diversity, with a view to generating recommendations on how cultural diversity can be maintained in the face of the global marketplace;
- √ expanding activities for preserving the traditional knowledge held by locally-adapted human populations for utilizing locally-available resources in a sustainable manner;
- √ enhancing IUCN's understanding of the relationship between national security and the environment, seeking to expand its collaboration with others working in this field;
- √ building stronger linkages among multi-national corporations, security, and the environment, based on the vested interest in maintaining environmental security in those areas of the world where multi-nationals trade and have their labour force bases;
- √ building its capacity as a technical advisor to the parties of international environmental conflicts which affect areas or species important for conservation, and attempts to resolve these equitably and peacefully. IUCN's roles might include providing technical advice to UN mediation efforts, advising on issues surrounding bilateral disputes over shared resources involving two or more countries, advising on conflicts over global commons via national sovereignty in natural resource use, and other similar issues;
- √ developing the capacity to articulate and implement a conservation agenda under circumstances of considerable insecurity, sometimes requiring approaches which go directly to communities rather than through governments;
- √ enhancing its capacity to work in the field of global change, in collaboration with the IUCN members working in this field, and

possibly using Africa as a focal point for examining the implications of world climate change, the characteristics and future course of desertification, the importance of arid-land and savanna ecosystems for biodiversity, and so forth;

- √ taking active steps to engage the commercial sector in relation to conservation, while reserving the right to scrutinize the behaviour of the private sector as it relates to conservation;
- √ becoming increasingly active in developing and applying economic instruments to address market failures and improve the distribution of costs and benefits of conservation measures;
- √ finding ways of stimulating greatly expanded public participation in the management of biological resources;
- √ developing an energy programme, including research on the environmental consequences of non-petroleum sources of energy, including such factors as sulphur-dioxide pollution from increased coal consumption, forest destruction related to firewood and bio-energy crops, problems with nuclear energy, and so forth;
- √ becoming a world leader in conservation-related information, building on the Biodiversity Conservation Information System to combine its information assets with a strict policy of objective and balanced analysis and assessment of policy options, to become widely recognized as the world's leading authority on defining sustainable development options and conservation policies.

5. CONCLUSIONS

Human-induced change has shifted from the agricultural transformation of the surface of the earth, to industrial mobilization of materials and energy, to the current mix of agricultural, industrial and advanced-industrial transformation. As this range of impacts has expanded, so has the secondary interaction among the changes and hence the complexity of the problems that they pose for biological systems. The impacts of human-induced change are no longer only local or regional, but now are global as well; but individual humans behave at the local level, calling for action to be focused here as well. All of this adds to the difficulty of assessing the human impacts on biodiversity, predicting the future, and defining the role of conservation organizations in the 21st century. The principles contained in Figure 5 suggest approaches that might be valuable.

Given the many possible and feasible views of the future, a sensible course of action would be the following:

1. Prepare for any kind of future, for example through continuing discussions, research, monitoring, and assessment;
2. Maximize the possibility that our preferred set of possibilities is realized, while doing whatever we can to ensure against even a small probability of the most pessimistic scenarios being realized;
3. Continue to refine our understanding of the possible futures, both by adding to our knowledge about the events which will determine the relevant characteristics of the future, and by familiarizing ourselves with the terms of debate over why these events should lead one way or another.

Figure 5: CONSERVATION POLICY AND THE FUTURE

Developing policy in the conservation field involves multiple dimensions; accurate scientific information is essential but not sufficient.

Policy reflects underlying values and beliefs about what is valuable and possible, thereby requiring an extensive process of consultation with various stakeholders.

Conservation policy orients conservation organizations towards a particular commonly desired future, and therefore requires both collaboration and creativity.

Policies inherently carry uncertainties with them. They build on an incomplete knowledge of the current situation, focus on the unknowable future, and emanate from human values and behaviour which are difficult to quantify and predict (and which often are in conflict with each other).

Conservation policies must include specific procedures for implementation and for evaluating the effectiveness of these policies.

Conservation organizations should prepare for the future on two related but distinct levels:

- √ first, building greater understanding of the degree to which past human actions have set in motion irreversible and ongoing change in the natural and physical environments, altering the range of options available to human communities; and
- √ second, building the capacity of human societies to understand, adapt and respond to environmental change, a function of the cultural, economic and political contexts in which they operate.

In other words, the world needs to maintain diversity in nature, in culture, in politics, and in economics. "Variety's the very spice of life, that gives it all its flavour".

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IUCN – The World Conservation Union

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As a Union, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. A central secretariat coordinates the IUCN Programme and serves the Union membership, representing their views on the world stage and providing them with the strategies, services, scientific knowledge and technical support they need to achieve their goals. Through its six Commissions, IUCN draws together over 6,000 expert volunteers in project teams and action groups, focusing in particular on species and biodiversity conservation and the management of habitats and natural resources. The Union has helped many countries to prepare National Conservation Strategies, and demonstrates the application of its knowledge through the field projects it supervises. Operations are increasingly decentralized and are carried forward by an expanding network of regional and country offices, located principally in developing countries.

The World Conservation Union builds on the strengths of its members, networks and partners to enhance their capacity and to support global alliances to safeguard natural resources at local, regional and global levels.

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