EXTINCTION GLOBAL CHANGE

Toward a Common Agenda for Biodiversity Conservation & Sustainable Development

SESSION III

SUMMER PROGRAM, 1991

ASPEN GLOBAL CHANGE INSTITUTE

ASPEN, COLORADO USA

BACKGROUND

The Aspen Global Change Institute (AGCI) was founded in 1989 to help scientists and policy makers understand and respond to global change and environmental issues. The ultimate goal of the Institute is to help all of us gain more accurate knowledge of our global environment and to foster responsible action to deal with the consequences of large-scale change.

AGCI offers a summer program which provides an in-depth forum for scientists from around the world to explore the latest understanding of the global environment and how human activities affect Earth systems. Each two-week session assembles a cross-disciplinary group of researchers from both the natural and social sciences to further knowledge of a selected topic in global change research.

A subcommittee of the AGCI Advisory Board selects the themes for the summer program (three, two-week sessions) as well as session chairs who represent expertise in those areas. The chairs then invite participants to attend their respective sessions. In 1991, a total of 101 participants from 13 countries attended the AGCI summer program in Aspen, Colorado.

Key to the dynamics of each group is the diverse representation of both cultures and disciplines. The result is exciting exchanges and insights into the knowledge base required to look at Earth systems from an integrated perspective. For example, remote sensing specialists in extended dialogue with vector-borne disease researchers explore the potential of combining field-based and image-based risk mapping for the design of integrated and effective disease control strategies. Universities and government labs rarely allow researchers to experience such cross-disciplinary and cross-institutional exchange.

Earth systems are not well understood. If we are to discern human impacts on the environment, such as increasing carbon dioxide concentration in the atmosphere, we must make a comprehensive global effort to further Global Change Science. It is imperative that we gather this information and share it with industrial leaders, educators, policy makers and the public at large to build a consensus on how to create an environmentally sound blueprint for the future.

AGCI session participants create an international network of scientists (summer program "alumni") who have been stimulated by and connected to other researchers they otherwise would not meet. The output of these synergistic sessions include national and international research collaborations, a series of reports available to the research community, science managers and public policy leaders, and the generation of educational materials for students K-12 through the Ground Truth Studies program.

SUMMER PROGRAM 1991

Session I Remote Sensing, Environmental Change and Human Health

Session II Biogeochemical Cycles and Population Dynamics

Session III Extinction and Global Change: Toward a Common Agenda for Biodiversity, Conservation and Sustainable Development

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Executive Summary

The destruction of natural habitats and the associated extinction of vast numbers of species is a global change of *unprecedented* magnitude with potentially disastrous consequences. One-half of all the life forms on the planet could be lost in a single human lifetime as a result of deforestation and pollution. The prime agent of global biotic impoverishment is undeniably the human population. Development policies and practices which do little to protect and conserve the natural resource base, including biodiversity, are at the core of a mass extinction event.

The bulk of the world's existing biodiversity is found in remote tropical forests and traditional agropastoral ecosystems. It is essential that steps be taken to maintain a wide variety of these ecosystems along a spectrum of conservation/use areas which are complementary in several ways, so that different systems meet different combinations of objectives. This report summarizes the discussions and conclusions of the Aspen Global Change Institute's third session of the 1991 summer program, on Biodiversity, Conservation and Sustainable Development, held in August 1991. The participants identified relevant unifying themes among scientific disciplines in an effort to contribute to a more comprehensive understanding of potential conflicts and linkages between biodiversity and development:

- The capacity of ecological assemblages to respond to natural change is a vital attribute of the biosphere. Species depletion, however, will challenge the ability of the biosphere to adapt to future climate change and may negatively affect human abilities to adjust to global warming.

- Misunderstanding, under-valuation or ignorance of local knowledge and management expertise, as well as local patterns of customary rights, often result in erosion of biological diversity and undermine sustainable development objectives.

- When products from or knowledge about biodiversity resources are passed directly to outsiders, appropriate economic benefits rarely accrue to the primary source population. Policies that promote secure local access to resources and long-term incentives for their use are best able to maintain biodiversity and sustain international development.

- Our knowledge of plant and animal species (particularly in the tropics), as well as their distribution, abundance, ecology and relationship to human well-being and development, is extremely limited. Biodiversity is inextricably linked to human resource use; understanding such linkages requires further integrated cross-disciplinary research.

- The objective of environmental education is to nurture environmentally literate world citizens. Recognizing that education is a two-way process, economically poor people in biodiversity-rich areas have substantial indigenous knowledge to share with and teach to the people of more developed countries.

Participants in this discussion offer recommendations furthering these efforts through policy changes, management, research and education.

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INTRODUCTION

Our biosphere is undergoing a change of significant proportions toward the mass extinction of up to 50% of all species in the next century alone. Approximately 1500 species, most of them unknown to humans, are being destroyed every year, a rate of disappearance that is hundreds, perhaps thousands, of times faster than the "natural" background rate of the past 600 million years (Myers, 1989).

Experts estimate that during the next 20-30 years alone, approximately 25% of all remaining species may become extinct (Ehrlich and Ehrlich, 1981; Raven, 1987; Soule, 1986), leaving behind relatively barren landscapes and a potentially unstable biosphere. Simply put, the loss of biodiversity represents a catastrophic and largely irreversible global change.

Biodiversity extends to all forms of life – from crop plants and domesticated animals to individual wildlife species and, ultimately, to human beings. Global change resulting from biodiversity depletion may be more critical to life on Earth than the projected effects of global climate change. Unlike biomass carbon sinks, a natural species – as we know it – cannot be replaced or recreated over meaningful human time scales. Once extinct, the valuable genetic and cultural information contained in a species is lost to the planet forever. Moreover, species extinction and habitat loss are inextricably linked to today's most pressing socioeconomic problems – exponential population growth, extreme poverty, landlessness, overconsumption of nonrenewable resources by industrial societies, widespread environmental degradation and pollution. While biodiversity is a global problem, it is of particular concern in tropical regions because of the extraordinary combination of rich biological and cultural diversity and the rapid increase in exploitation pressures across the region.

In contrast to global climate change, the causes of biodiversity loss are generally agreed upon, and can be traced to humans. Human beings, in attempts to improve quality of life for the short-term, have appropriated and converted vast areas of the globe for urban settlement, mono-cultural crop production and industrial development. Consequently, our activities are resulting in the depletion of biodiversity at unprecedented rates and scales.

While people have caused mass extinctions, we have also demonstrated that we are equally capable of slowing and reversing the destruction of biodiversity. Conserving and restoring the planet's natural habitats, however, will require us to adopt a very new set of values and priorities related to socioeconomic justice and the environment. Highly innovative compromise between economic development, equity and environmental protection objectives will be essential.

In recent years, we have begun to recognize and better understand linkages between biodiversity and development. Such linkages have fostered the pre-eminent paradigm for conservation science over the past decade. The applications of this science are directed toward the mitigation of conflicts through socially and ecologically sound conservation and development. This session of the Aspen Global Change Institute was convened in recognition of the importance of biodiversity loss as an irreversible and potentially catastrophic form of global change. Its mission was to assess the state of knowledge and activities in the field and to make recommendations for future action. This document represents a synthesis of thinking in this area from a diverse membership of natural and social scientists and educators.

General Principles

There are several fundamental tenants that should be accepted *a priori* in any consideration of the linkages of biodiversity and development. The following principles support a paradigm for biodiversity conservation and sustainable development science and application.

- Biodiversity is fundamental to the maintenance of critical evolutionary processes, as well as to the healthy, sustained functioning of virtually all ecological systems at all scales.
- Biodiversity represents the primary resource base for all sustainable human development.
- Biodiversity and cultural diversity are closely interrelated. The current and future status of biodiversity depends upon human actions moderated by our various cultures.
- Biodiversity is affected adversely by the unparalleled global increase in human population. While rapidly growing populations in developing countries will inevitably require more land and resources – with undeniable impacts on local biodiversity – high consumption societies must bear primary responsibility for current resource depletion trends, despite comparably lower rates of population increase.
- Biodiversity has evolved under conditions of change at variable scales and magnitudes in reaction to the impacts of geologic, climatic and human activity on the Earth. The current rate and scope of human-induced environmental change, however, is overriding the inherent ability of species, societies and systems to respond to change in order to maintain balance.
- Biodiversity conservation requires environmentally literate populations which are knowledgeable about species diversity; ecological relationships and linkages between patterns of resource consumption and conservation. New and more effective forms of environmental education and training are keys to attaining this level of literacy.

Definitions

Biological diversity (biodiversity) refers to the variety of the Earth's living organisms, their genetic components and the ecological systems which they inhabit. It is an integral part of all the planet's ecosystems — temperate grasslands, arctic tundra and deserts, as well as the more species-rich coral reef communities and tropical moist forests. From a purely human perspective, biodiversity is the foundation of our life-support system and the basis for sustainable development.

Sustainable Development refers to progressive transformations in societies and economies that are designed to meet the human needs of the present, particularly those of the world's poorest nations, without compromising the ability of future generations to meet their own needs (WCED, 1987). Sustainable development takes into consideration access to resources, degradation of the environment and distribution of costs and benefits over time.

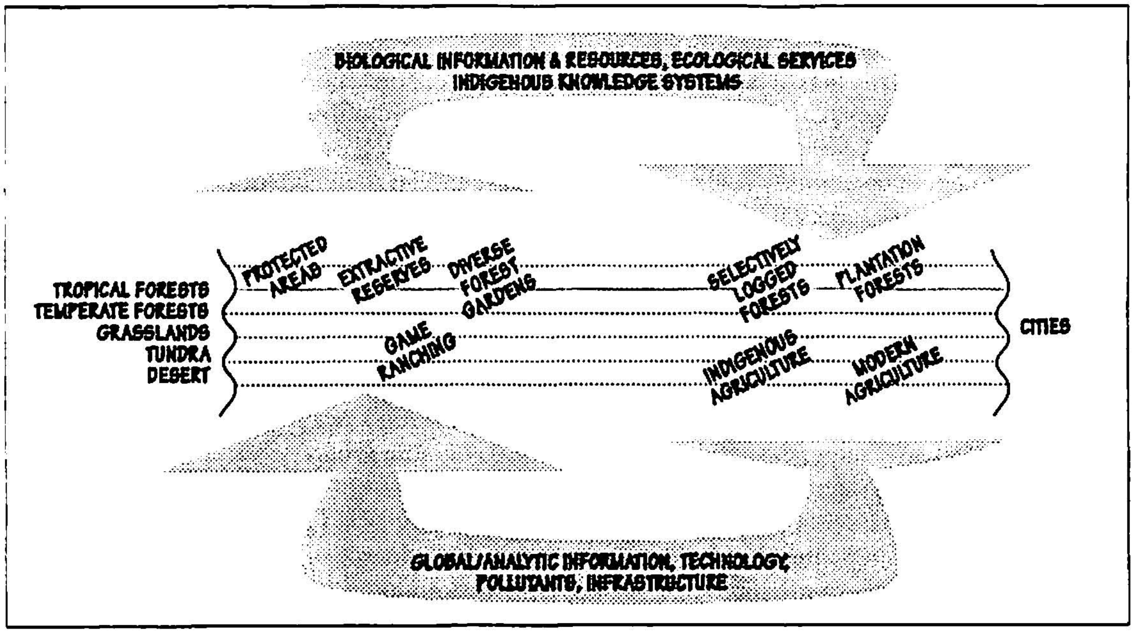

Figure 1
Biodiversity Continuum Based on Intensity of Human Use

Conceptual Framework

Biological diversity is found along a continuum that ranges from wild, uninhabited areas (globally high in biodiversity) to urban, industrial areas (globally low in biodiversity). The vast bulk of the world's biodiversity is found in remote wildlands, forests and traditional agro-ecosystems and nomadic systems. As the global economy expands into these areas, the leading edge of modern agricultural systems and urban industrial areas, low in biodiversity, is encroaching rapidly on previously remote areas.

As a framework for examining these relationships between biological diversity and development, one can conceptualize a series of ecosystem types arranged along a continuum of intensity of human use or modification (Fig. 1). From left to right along the continuum, ecosystems can be characterized from the extremes of wild to converted, with systems of intermediate modification found between. Such a spectrum is multi-banded, i.e. separate bands indicate different biomes or lifezone systems (e.g. tropical rain forests, grasslands, tundra, etc.).

Maintenance of a variety of systems along the spectrum results in a mosaic of conservation/ use areas which are complementary in several ways:

- Discrete systems along the continuum meet various combinations of objectives concerning biological conservation and development. Some of these objectives conflict and cannot be addressed simultaneously within a single system. Many objectives, however, can be achieved within a suite of systems.
- Effective and sustainable systems at any point along this spectrum are dependent on functioning systems at other points. For example, diverse agricultural systems are often dependent on biodiversity and ecological services provided by less-modified

systems; conservation of wild areas is dependent on stabilization of land use in more modified surrounding systems.

- Diverse systems across and along this continuum ensure conservation of genetic, ecological, cultural and economic diversity. In addition to the intrinsic values derived from individual components, diversity at all of these levels provides a basis for adaptation to changes at many scales and frequencies. Given the need for both conservation of biological diversity and sustainable development, maintenance of a variety of systems along the continuum is vital.

Conservation of biological diversity on a global scale requires consideration of the total diversity – *across* all bands of the continuum, as well as *along* each one. As described above, the wild states of the various biomes are characterized generally by very different levels of diversity. For example, tropical forests and coral reefs are far more species-rich than boreal forests or temperate lakes. As a general rule, the greatest variance in biodiversity among systems of generally equal modification — but under different management practices — is likely to be in the intermediate zone (Fig. 2). Higher variation at these intermediate levels indicates that here, given a determined degree of modification, choices concerning management practices are most open to promotion or degradation of biodiversity.

People who live on the margins, where disturbance is encroaching on biodiversity-rich areas, rapidly find themselves converting from a "traditional" to a "modern" existence as the global market economy penetrates into the shrinking periphery. Under "traditional" existence (Scott 1976), conditions reflected relatively high biological and cultural diversity, a locally-based economy, dependence of the poor on nature for goods and services, low cash needs, high value placed on biodiversity, high locale-specific knowledge of nature, local "legal" control of resources; traditional conservation systems and a "subsistence ethic" (Fig. 3).

After the transition to "modern" culture, we find relatively low biological and cultural diversity, a market economy, dependence of the poor on the state for jobs, high cash needs, dependence on few species and habitats, preference for low diversity, poor knowledge of nature, legal state control of resources, unstable "bullets and barbed wire" conservation systems, conversion of nature to capital or commodities for sale, and the emergence of the capitalist ethic.

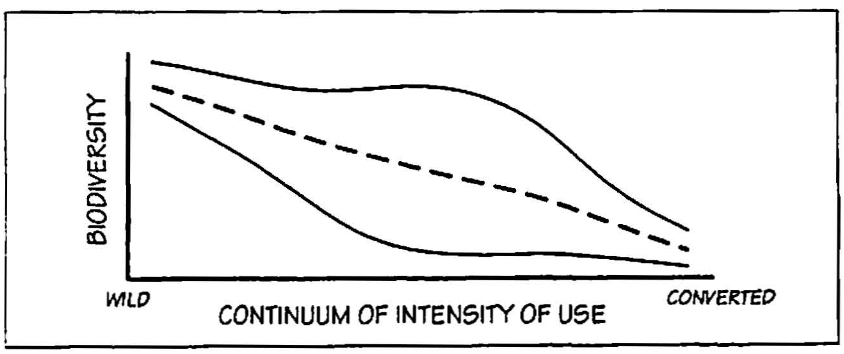

Figure 2 / Variation in Biodiversity Along Continuum Bands

Using tropical rain forests as an example, the biological diversity of little-modified forests is high, with a relatively small range of variation. Under management, diversity of such forests may decline a small or great amount, depending on the types of management practices adopted. For example, many swidden systems of agriculture result in higher levels of diversity than do more permanent small holder plots.

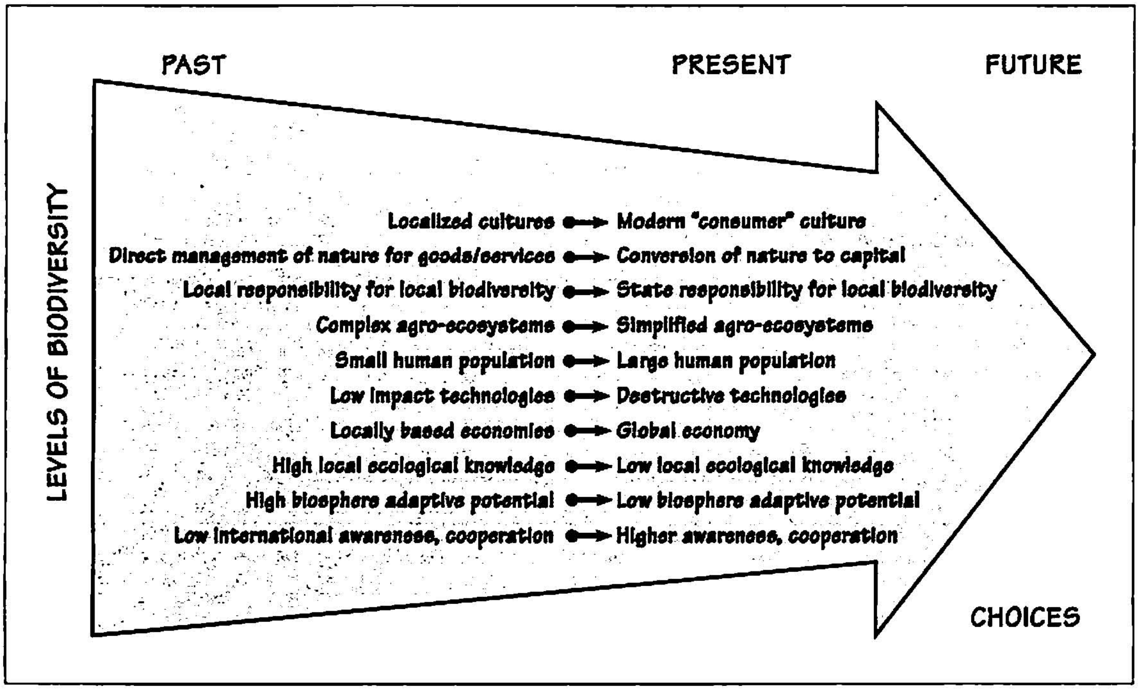

Figure 3 / Global Temporal Trends Related to Biodiversity

Cultural, economic, political, agricultural and technological changes have negative impacts on biodiversity. These factors, including human-induced climate change are, in the final analysis, reducing the biosphere's adaptive potential. Fragmentation of the landscape, erosion of genetic diversity and rapid habitat change all reduce the biodiversity available – for human use and maintenance of relatively stable biosphere conditions in coming centuries – and for the evolutionary engine driven by selection and genetic drift. Increasing levels of global communication, cooperation and treaties, however, offer new opportunities for responsible resource management.

Unifying Themes

There are many different stakeholders along the biodiversity continuum. Development can serve the needs of a few or many. As members of the scientific community endeavor to contribute to a more complete understanding of these potential conflicts and linkages, they also must identify unifying themes and concepts among disciplines.

What follows is an analysis based on six major themes:

I Global Change
II Sustainable Development
III Equity
IV Policy and Resource Management
V Research
VI Communication

THEME I: GLOBAL CHANGE

Change at all time scales is fundamental to the Earth's climate and to all life. Evidence from the fossil record suggests that, by adjusting abundance and distribution, plants and animals generally respond individually to the continuous and often large shifts in climate that have characterized the Quaternary period (the past 2.4 million years). Through time, these biological responses have produced many ecological assemblages – the most recent examples being modern biomes and communities that developed within the past few thousand years. This ability to respond to natural change is an essential attribute of the biosphere and the millions of species inhabiting Earth.

Impending global changes, however, will challenge the extent to which the biosphere can adapt to future climate change. These changes also may affect human abilities to adapt to major environmental changes. Human activities of the past few centuries –especially post-WWII – have produced unprecedented new environmental conditions. Scientists project that global climate change, resulting in part from human-induced changes in atmospheric chemistry, will be different from any changes that occurred during the past 10,000 years. Landscapes over which continent-scale biotic reorganizations normally would take place have been fragmented extensively by land-use practices that interfere with natural systems in many parts of the world.

Although climate change, *per se*, has not destroyed biodiversity in the past, broad-scale destruction of biodiversity today may well affect the ability of the biosphere to adapt in a way that can provide a habitat capable of supporting large human populations, at least at current standards of living.

EXTINCTION FACTS

- Tropical forest biomes are being deforested at a rate of greater than 1% annually, which may ultimately involve the extinction of roughly 50% of all species.
- High diversity coral reef and wetland ecosystems are being depleted even faster than forests.
- Each year, an area of about 6 million hectares of land (nearly twice the area of Belgium) is degraded beyond practical hope of restoration.
- The vast majority of tropical forest depletion can be attributed to four human activities: logging, fuel-wood gathering, cattle ranching, and slash-and-burn cultivation.

Sources: Brown, 1989; Myers, 1989; OTA, 1987

Case Study

Satellite Monitoring of Tropical Forest

Remote sensing offers the potential for monitoring the tropical forests of the world. Landsat technology has been available since the early 1970s, providing data with which to map general forest type and area. The U.S. Government has dedicated considerable effort and resources to transferring LANDSAT data interpretation techniques to tropical countries; yet the operational use of these data is yet to be fully realized. The financial resources of national forest monitoring agencies have been inadequate to permit extensive use of remote sensing technology to augment conventional methods of forest monitoring. Efforts to commercialize data from space in the 1980s continues to limit data availability in the 1990s.

While coverage of critical areas in the tropics has been limited, there are specific examples, such as in Brazil and India, where national satellite data collection policy and satellite-based forest mapping have provided comprehensive national mapping projects. Additional high resolution data from the French SPOT satellite has provided increased potential for data acquisition, but as with the LANDSAT system, the use of the data is constrained by prohibitively high pricing. The development of coarse resolution satellite analysis, has led to improved monitoring capability of forest fires and vegetation status. The launch of the European Earth Remote Sensing Satellite (ERS-1) microwave system holds additional potential for monitoring the tropics.

Today's concerns about global change and biodiversity are leading to increased attention to the tropical forest regions and there are several efforts underway to provide improved estimates of deforestation. For example, a U.S. Interagency Initiative led by NASA was developed in 1991 to provide improved data coverage and interpretation of current and historical LANDSAT data for a large portion of the tropical belt, with the objective of contributing more precise information about global carbon fluxes. The European Community is planning an international collaborative effort to produce a global map of the tropical moist humid forests using 1km spatial resolution data from the National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometer (AVHRR) sensor.

Our current knowledge of the extent and the rates of change of the world's tropical forests is poor. Statistics most often quoted are those produced by the United Nations Food and Agriculture Organization in 1980 as part of their Tropical Forest Assessment (TFA). These data were a compilation of existing national statistics with very little primary data generation. In some cases, the national estimates were derived from maps and data sources generated several years before the assessment.

The statistics for Zaire, for example, were produced largely from maps made in the 1950s. As part of the 1980 TFA, a remote sensing demonstration study was produced for Togo, Benin and Cameroon using LANDSAT data which generated new information. The approach, however, was not continued or expanded to provide comprehensive mapping of countries where the existing statistics were clearly inadequate.

Since the 1980 assessment, new regional and global statistics have been gathered and have, at best, offered educated guesses as to the remaining area of forest and rates of deforestation. Some of the more advanced national monitoring programs have provided up-to-date remotely-sensed base maps of forest resources, but such studies have been limited to a small number of countries within the tropical belt. There is now a need for the space agencies, satellite data providers and the forest monitoring agencies to work together to implement effective operational monitoring of the global tropical forests.

Case Study

CONSERVATION LESSONS FROM THE GEOLOGIC RECORD

Global climate of the past 2.4 million years ("The Quaternary Period") has undergone regular glacial cycles, which are driven by variations in insolation associated with the Earth's orbital parameters. Each of these cycles experiences a process of:

- gradual cooling
- development and expansion of continental ice sheets to maximal, but unstable, positions
- rapid collapse of the ice sheets
- relatively brief warm period (interglacial)

The last nine of the glacial cycles have had a dominant frequency of 100,000 years; earlier cycles were closer to 40,000 years. Superimposed on these relatively long oscillations are high-frequency variations at time scales of centuries, decades and years. Paleo-ecological reconstructions demonstrate that vegetation has varied almost continuously with the fluctuating climates. Through time, the individualistic responses of taxa to changing conditions have led to reorganization of biotic associations at local, regional and even continental scales – changes that are variable in rate, but virtually continuous. Particular biotic assemblages that exist today have little intrinsic evolutionary significance because they were shaped largely by the conditions of the present interglacial period – itself a highly unusual time in recent Earth history. This and other interglacial periods account for only 10% of the time during the past 2.4 million years; the remaining 90% of the time experienced colder, "ice-age" conditions.

Hunter et al. (1988) proposed a new approach to maintaining biological diversity based on some of the perspectives gleaned from Quaternary paleo-ecology, especially evidence from fossil pollen stratigraphies (studies of the different types and amounts of fossil pollen in different geologic layers, see also, Graham 1988). These stratigraphies indicate that plant taxa have responded to past climate change with highly individualistic changes in ranges, and thus cannot be members of tightly evolved communities that persist for long periods of ecological or evolutionary time. Therefore, the protection of biota or a representative array of communities should be based on consideration of physical environments as arenas of biological diversity, rather than on the particular assemblage of species temporarily occupying those environments.

The prospect of global change engenders two further suggestions. First, nature reserves should encompass a wide range of physical environments to allow organisms to adjust their local distribution in response to long-term environmental change. Second, nature reserves should be connected, ideally by large-scale (continental) corridors, to allow species to change their geographic distributions in response to major changes in climate – much as they have in the past.

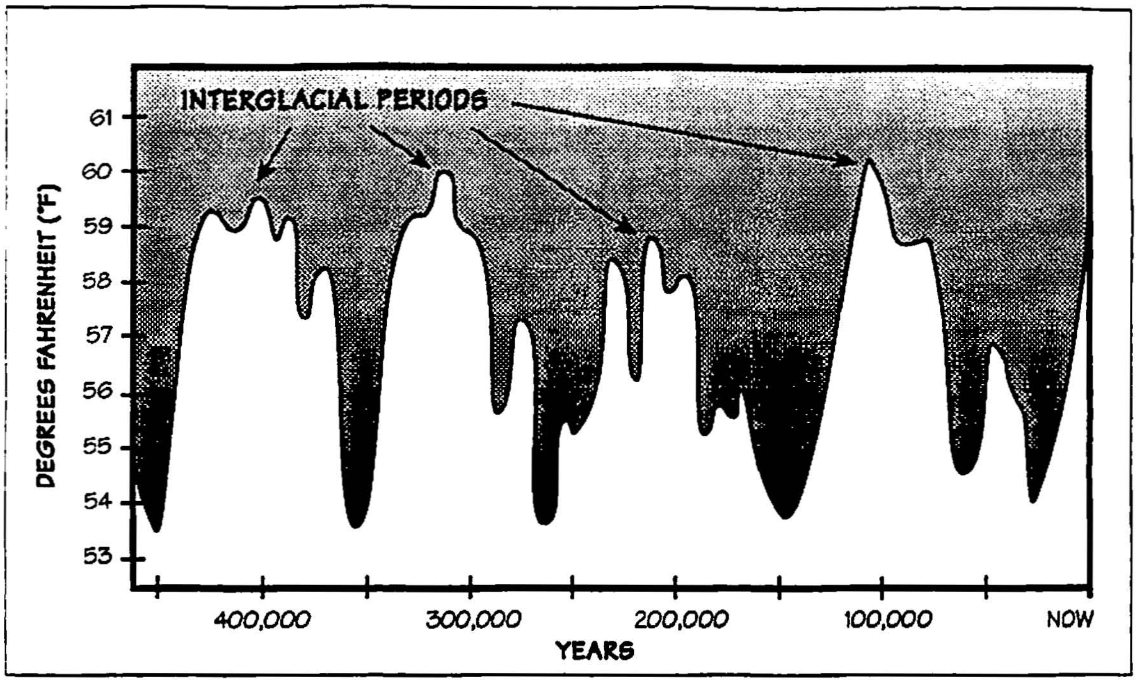

Figure 4 / Average Surface Temperature of the Ocean in the Most Recent 450,000 Years
This graph is based on a variety of geological techniques as compiled by the National Academy of Sciences (Future Weather and the Greenhouse Effect, by John Gribben, page 31).

Theme II: Sustainable Development

Development is a legitimate human aspiration and goal for any nation and for any people. Development efforts invariably have an impact on biodiversity which can be either positive or negative. Conventional development strategies seeking to improve our well-being by raising the GNP, however, do not usually value biodiversity. Economic development typically promotes growth without qualitative improvements. Most large-scale development projects have directly or indirectly eroded biological diversity. The loss of biodiversity generally undermines development objectives, particularly in rural sectors. Ultimately, integrated conservation and sustainable development projects have the best chance of conserving our planet's biodiversity.

Cost-benefit analyses normally assess only the short-term potential market values of biological elements considered as natural resources. Alternative models that include concepts of future options and long-term sustainability (e.g., Daly & Cobb, 1989; Odum, 1988), subsistence value and food security issues warrant serious consideration by multinational development banks, other development agencies and national governments. Beyond traditional economic values, other development-related values are being increasingly recognized. These include aesthetic, scientific, heritage and ethical values. Though it is difficult to quantify these values, attempts are being made to integrate existence values and inter-generational equity into economic analyses (Norgaard, 1991).

Local organizations are more successful at meeting the development needs of communities while conserving biodiversity. When local participation is involved from early planning through implementation stages of projects, their chances of effectiveness increase. Experience has shown that local knowledge of use and management of biodiversity can be successfully incorporated into both conservation and rural development projects. Conversely, failure to acknowledge and utilize valuable local resources can be devastating for sustainable development. Misguided development policies that result in non-sustainable resource uses reflect external forces such as pressures to service foreign debts. Some innovative programs, such as conservation trusts and debt-for-nature swaps, can help alleviate these pressures.

New technologies offer considerable potential for improving biodiversity management. Yet transfer of technology for monitoring environmental change (e.g., remote sensing, natural resource indicators, monitoring) and organizing environmental information (e.g., geographical information system) often fail. Ironically, technologies that degrade biodiversity have been readily accepted. Environmental costs and benefits of technology applications are seldom analyzed and evaluated in development projects.

Some technological innovations banned in developed countries are still manufactured for export to lesser developed countries, where applications of the technology are uncontrolled (such as unidentified, dangerous pesticides sold in unlabeled containers). Recently, more biodiversity-friendly technologies (such as integrated pest management and pollution reduction) are entering the technology transfer track.

Case Study

Tropical Forest Management and Biodiversity

The Palcazu project is an innovative sustainable development project based on the management of species-rich tropical forests in a small Peruvian valley at the western edge of the Amazon basin (Hartshorn, 1989), see figure 5, page 20. The tropical rain forests in the lower valley (300-500m elevation) average 185 tree species per hectare (for all trees 10cm or more in diameter at breast height) and there are an estimated 1,000 species of trees in the small (20 x 70km) valley. Land-use capability of the lower valley gives the following maximum sustainable uses; seasonal crops (7.6%); pasture (13.3%); perennial crops (14.4%); production forestry (46.2%); and protected forests (18.6%).

Approximately 60% of the 6,000 inhabitants of the Palcazu valley are Amuesha Indians grouped in 11 native communities. Nearly half of the natural forests in the lower valley that are suitable for production forestry are on land controlled by the Amuesha native communities. Virtually all of the steep lands above 600m are in the Yanachaga-Chemillen National Park, two protection zones and a communal forest reserve; the latter for, and under the control of, the Amuesha Indians .

Prior to initiating the Palcazu project, local land use was mainly in extensive pastures for beef cattle. Amuesha Indians were entering into cattle raising through share cropping offered by the economically-dominant colonists. Thus the lower valley was at the threshold of significant deforestation due to the preference for cattle as one of the few economically-viable activities for colonists and Indians. The Palcazu project offered the Amuesha an alternative to cattle ranching: sustainable forestry. The Yanesha Forestry Cooperative (COFYAL) was formed in 1986 by five native communities and nearly 100 individual Amuesha members as a mechanism to organize the production forestry activities and distribute the profits from selling processed timber. COFYAL is the first forestry cooperative in the Amazon basin.

In order to add value to typical forest products such as timber, a small processing center was built on land ceded by the Shiringamazu native community to COFYAL. Processing capability includes a small sawmill, a portable charcoal kiln, and a separate facility for preserving round-wood (5-35 cm in base diameter). Preservation of posts and poles is done with a presCap that fits over the base of a debarked pole and uses hydraulic pressure to replace the sap with a preservative. Of the 250 cubic meters of harvestable timber per hectare, about 60% goes to the sawmill and 40% for round-wood preservation. Unusable timber and scraps are converted to charcoal. Local processing enables COFYAL to market virtually all the timber from their production forests.

Natural production forests in Amuesha native communities are managed by the strip clear-cut technique. This technique promotes outstanding natural regeneration of hundreds of native tree species. The majority of tropical American tree species appear to be dependent on natural gaps in primary forests for successful regeneration. Furthermore, most of the light hardwoods and many of the heavy hardwoods (e.g., Swietenia, Diplotropis) are gap-

dependent species. A strip clear-cut is an elongated gap that simulates the natural gap phase dynamics of tropical forests. Two demonstration strips (<.5 ha) established in the Palcazu valley in 1985 had over 200 tree species in less than three years after clear-cutting. The number of tree species per 10 x 10m subplot averaged 40-50 species. The strip clear-cut technique is an excellent means of maintaining tree species diversity in tropical forests.

The Palcazu forestry project is integrated vertically and horizontally. Vertically, the Amuesha native communities through COFYAL control their production forests, process the timber locally and market sawnwood, preserved posts and poles and charcoal to a variety of markets. Horizontally, the Palcazu project integrates ecological, economic and socio-political principles into a production system for the sustainable development of tropical forests that conserves local biodiversity and counters tropical deforestation.

Population and Consumption

- Since 1900, the human population has increased three-fold and consumption of fossil fuel energy has increased 12-fold.
- Population growth is greatest in the tropical regions. For example, the population of Rondonia in the southern Amazon has increased ten-fold between 1975-1986.
- Humankind currently appropriates about 39% of the Earth's net terrestrial primary productivity.
- The average North American utilizes 150 times as much energy and other natural resources as an average Bangladeshi, Ethiopian or Bolivian.
- If everyone adopted eating habits common in the United States, the planet could produce only enough food to support about half its current human population.
- The greatest population explosion is still to come.

Sources: Brown, 1989; Kates et al., 1989. Myers, 1989, 1990; Vitousek et al., 1988

Figure 5 / Palcazu Project Location

THEME III: EQUITY

Equity issues affect biodiversity conservation at multiple levels and must be viewed from a broad perspective. The majority of the planet's biological wealth is found in poor, economically less-developed countries, while the financially wealthy nations tend to harbor much less diverse biota. For example, Ecuador is one of the poorest countries economically and yet one of the richest from the standpoint of its biodiversity. There are grossly unequal economic relations between the less- and more-developed countries; the latter control both terms of trade and conditions of debt. More-developed countries have an interest in preserving biodiversity, while less-developed countries seek to share of the costs of the burden.

While inequity is a serious problem for North-South relations, it also is a problem *within* many nations and cultures. Where there are established elites controlling access to land and other resources, the development potential of less-favored populations inevitably is limited, forcing them into more marginalized forms of existence and ultimately into direct conflict with conservation interests.

Most nations claim ownership of nearly all forest and aquatic resources located within their territorial limits, encompassing most natural habitats rich in biodiversity. Nations usually ignore, however, the customary property rights held by many of the more than one billion people (approximately 20% of the world's human population) who are directly dependent on tropical forests and near-shore marine resources. Governments in developing nations frequently lack the administrative, technical and/or financial capacity required for conservation and development.

There is a pressing need to create and/or recognize existing local-level, short- and long-term incentives that promote the sustainable use of natural resources. Partnerships between state and community offer opportunities to overcome these problems. Policies that promote secure local access to resources and long-term incentives for their use are best able to maintain biodiversity and sustain economic development. One effective and cost-efficient response entails the recognition of existing, community-based customary property and/or marine rights based on long-term occupancy. Another option is granting community rights through social forestry and community fisheries programs.

In many traditional cultures, knowledge of particular qualities and uses of plant and animal products represents a form of accumulated wealth. When these products, or knowledge about them, is passed to outsiders, the benefits rarely accrue to the primary source population. Acceptance of the twin concepts of "genetic patents" and "intellectual property rights" – while complicated – would help to reduce this inequitable situation.

Success or failure in achieving conservation is related to ethical commitments that influence decision-making. Communities dependent on biodiversity traditionally operate under a subsistence ethic (Scott, 1976) that defends biodiversity and recognizes human rights to subsistence. Modern cultures, however, value nature as something that can be converted to capital for investment elsewhere. Unless modern cultures reincorporate an ethical commitment to maintenance of a common human planetary resource base of which biodiversity is an integral component, future options for economic development will be increasingly limited.

Finally, from the philosophical field of ethics, the concept of intergenerational equity holds that human populations have an obligation to pass on the fullest possible range of resource use options to future generations. Wider adoption of this ethic has clear implications for the conservation of biological diversity across all current cultures and populations.

Case Study

COMMUNITY-BASED CONSERVATION IN THAILAND

Throughout the world, outsiders overlook biodiversity management by rural residents within traditional conservation systems. National governments, eager to generate income from forests, deny communities the right to forests they traditionally have occupied. Thailand provides an illustrative example (Lynch & Alcorn 1991).

Community forests here are administered by user-groups, but communities do not have legal tenure to these lands. Management of most community forests consists of selective protection; i.e. there is minimal interference with the natural forest. From their forests, farmers reap the ecological services of watershed protection, as well as a wide variety of nonwood forest products including foods, medicines, craft and construction materials. Surveys of villages with community forests reveal that half of the annual household consumption needs are met from forest products, either directly or from cash derived from their sale. Communities regulate harvesting, while villagers take responsibility for watching for illegal activity in the forest and for arresting and fining those who violate the rules.

But in spite of such conservative use, hill tribes are, in effect, punished for their protection of forests – their lands are being declared protected areas; rights of residence are denied, along with rights to maintain the forests. A recent effort to extend the protected area system to include 15% of the land area led to the inclusion of still more villages inside the boundaries of National Parks. In a typical case, the cultivated lands, the traditional irrigation system and the forests of villages in Wang Nua District of Lampang province were incorporated into Doi Luang National Park in April 1990. While villagers have 90 days to protest by law, they were not notified of the demarcation until the deadline had passed. Even district level officials were not informed of the demarcation.

The Thai government now is considering giving communities long-term leases for community forests, but only if the forest is certified as "degraded." Debate continues. A recent analysis of biodiversity conservation in Thailand (Lohmann 1991) concludes that villagers, not the state, are the principal defenders of biodiversity.

Theme IV: Policy and Resource Management

Policy and resource management can be the most serious constraints to conservation and wise use of biological diversity. The exploitation of natural resources often is based on a misperception that these resources are unlimited, resulting in laws and regulations that promote resource depletion. Management in the broadest sense affects most natural systems. Virtually all systems are influenced either directly or indirectly, by various combinations of policies, practices and cumulative effects of human activities.

Policies promoting secure local access to resources and long-term incentives for their use are best able to maintain biodiversity and sustain development. The integration of local resource management strategies, such as extractive reserves, village lake and forest reserves into regional and national level programs, is important for their effectiveness and long-term success. Sustainable resource management systems are those that are well adapted to local social and ecological conditions, while oriented to the maintenance or enhancement of biological diversity.

A trend is growing in the international development community to include biodiversity concerns in program portfolios. Biodiversity projects, however, tend to be isolated or marginal to core development issues. Furthermore, international organizations usually do not include a specific program focus on integrating biodiversity conservation with sustainable development.

Case Study

Mountain Gorillas and Multiple Use

The African nation of Rwanda has proven to be an excellent laboratory for testing efforts to integrate conservation and development interests since the late 1970s. Covering only 26,338km^2 of rugged terrain, landlocked and void of major mineral resources, Rwanda has been forced to depend on its rich land resource base to satisfy both the subsistence and development needs of its population, 90% of whom work in the farming sector. This task is complicated by a human population density of more than 300 per km^2 and an annual population growth rate of 3.7%. Yet, despite such pressure on the land resource base, more than 16% of Rwanda remains in natural savanna, wetlands and forests, providing critical habitat for a surprising diversity of species. Resolving the conflicts inherent in this situation is the principal challenge of several development projects.

The Virunga volcanoes rise to heights of 4,500m along a 65km range in northwest Rwanda. Covered with rain forest and alpine plant communities, the area was set aside in 1925 as Africa's first national park in an effort to preserve the rare mountain gorilla. Fifty years later, though much more is known about this special creature through the work of George Schaller and Dian Fossey, its endangered status is further heightened by a nearly 50% population decline to barely 250 individuals.

Faced with the prospect of their imminent extinction, an interdisciplinary research project was undertaken to study the causes of the gorilla's decline and to recommend appropriate courses of action based on the results. The first part of this study involved classic conservation biology. The results of a new census, combined with existing long-term data on population dynamics, showed the clear effects of poaching and habitat loss.

The second part of the research initiative focused on social, economic and political factors affecting gorilla conservation. Beyond the obvious problems related to overpopulation, poverty and landlessness, several other key issues emerged in the course of the study. First, local populations perceived no inherent value – scientific, esthetic or moral – in wildlife or forest preservation, *per se*. Among non-consumptive economic values, only a minority cited tourism, probably because annual park income totalled only a few thousand dollars. As a result, political authorities permitted clearing of almost 40% of the Parc des Volcans in the late 1960s, and a majority of the local population wanted another 33% for a cattle ranching development scheme in 1979.

Armed with this information and faced with continued poaching and the prospect of more forest conversion, a multi-faceted effort to save the gorillas was conceived in 1979. Known as the Mountain Gorilla Project (MGP), this initiative had three key components:

- hiring, equipping and training guards to control poaching and illegal forest use
- education to increase understanding of conservation issues and to affect local attitudes toward wildlife
- tourism development, focused on gorillas, to generate employment and revenue at local and national levels

Although results in each sector were impressive, the tourism program was the driving force behind conservation over the next decade. In 1989 alone, more than 6,000 visitors paid over $1 million in direct park entry fees to see wild mountain gorillas, while spending an additional 3-5 million dollars in the course of their visits to Rwanda. This, in turn, generated several hundred local jobs and a significant increase in popular goodwill, not to mention the political will of Rwandan authorities to take seriously their commitment to conservation. Not coincidentally, the mountain gorilla population increased dramatically during the 1980s, from its low of barely 250 to 320 individuals – still endangered, but faring far better.

Although initiated by non-governmental organizations in collaboration with the Rwandan government, the success of the MGP in balancing conservation and development through tourism also attracted the interest of international development agencies in the late 1980s. The U.S. Agency for International Development, in particular, provided both direct support to the project and, perhaps more significantly, indirect assistance through efforts to improve general land resource use in the Ruhengeri watershed outside of the park. While the results of this latter initiative remain to be seen, a similar partnership already has proven effective in a parallel project in the Nyungwe Forest in southern Rwanda.

Case Study

WILDLIFE ISSUES IN WESTERN NORTH AMERICA

Yellowstone National Park and its ecosystem can be used to illustrate many of the land use issues which surround the conservation of biodiversity in the developing world. Yellowstone is our oldest national park (in a real sense, the oldest in the world), partly because of its spectacular natural resources. These include threatened and endangered species, such as the grizzly bear, bald and golden eagles, bighorn sheep, bison and (possibly) wolf. The park covers over 3,000 square miles – one of North America's largest protected areas.

At about the time the park was constituted, the indigenous native Americans were dispossessed of the land in the area. Ranchers came to the valleys to graze cattle. Stock and people-threatening predators were killed by the ranchers and the early guardians of the Park. Despite efforts to institute controlled hunting of big game, irrevocable changes transpired. Wolves were extirpated in Montana by the end of the Second World War. The range of the northern Yellowstone Elk herd eventually exhibited some of the most overgrazed land in America.

In contemporary times, land use/biodiversity issues are as volatile as ever. Ranchers do not want a return of wolves; villagers who run concessions, garages and other tourism-related services want fire protection; hunters do not want elk culled to preserve the degraded range. Meanwhile, the American public at large witnesses the controversies with little understanding of the issues surrounding their flagship park.

Fortunately, it appears that in the 1990s, for the first time, the entire ecosystem is being considered as a meaningful management unit. Public discussion is facilitating communication between custodial and user communities; Greater Yellowstone Interagency Management committees also are dealing with research needs. Under proposal are such issues as introducing wolves back into the system. It remains to be seen if this new, integrated approach to the entire system will result in more equitable management or in a restoration of former diversity. There is more hope now than in the past, however, because of an approach which addresses the seminal problem – an incomplete island of diversity in an increasingly allocated landscape. Similar situations in the developing world abound.

THEME V: RESEARCH

Over the last 10 years there have been significant advances in our understanding of biodiversity. There are still, however, major gaps in our knowledge. For example, we do not have complete biological inventories for any place on Earth; we know very little about the interdependence of species within discrete communities; and we can only speculate about the ability of fragmented communities to reorganize in response to human-induced and natural climate forcing. Research is fundamental to integrating the objectives of sustainable development and the conservation of biodiversity, and to understanding their inter-relationships.

Biodiversity is linked inextricably to human resource use. Understanding these linkages requires directed orchestration of cross-disciplinary research. Currently, there are major obstacles to conducting truly cross-disciplinary research in terms of the disciplinary orientation of funding agencies and research institutions. Furthermore, there are several institutional gaps for the support of the necessary research and development. Cross-disciplinary research that focuses on integrated conservation and development projects requires long-term vision and planning; it can not be accomplished on the short funding cycle (generally three years) offered by most research institutions.

The current knowledge-base associated with previous research and development experience is not readily available to those concerned with resource management. Mechanisms for project reporting and evaluation of development projects result in information that is not accessible. In addition, procedures for incorporating and transforming the results of scientific research into appropriate policy are inadequate, often resulting in an institutional chasm between research and policy.

Our knowledge of tropical plant and animal species, as well as their distribution, abundance, demography and paleoecology is extremely limited. Reliable and quantitative inventories are fundamental to the study of biodiversity in all systems. Linking the results of biodiversity research at different scales is inherently problematic and has yet to be adequately addressed by the research community. Remotely sensed data have the potential to focus on some of the questions of scale. The availability of high resolution satellite data most appropriate for this type of research is effectively limited to the research and development community by exorbitant cost, with incomplete and non-systematic data coverage, thus hindering up-to-date inventories of biodiversity and rates of change.

Traditional resource use is often ignored in the development of management strategies. Recent research has shown that there are considerable benefits to incorporating traditional methods of resource use and management. Research on practices relies on descriptive approaches. The variation inherent in biodiversity and resource utilization presents problems for research to identify generally applicable approaches to resource management. Local-scale research appears to provide the most promising results. The challenge is to coalesce local management approaches with regional management schemes.

There is a consensus that long-term monitoring will be required to fully evaluate the effects of human impacts and climate forcing on global biodiversity. The strategies for long-term monitoring must focus on critical areas of unique and/or high biodiversity and key environmental gradients, rather than on indicator or specific species. Long-term monitoring will be required to assess the sustainability of development in the context of conserving biodiversity. Most research and development projects do not include a monitoring component, let alone the long-term monitoring crucial for assessing change, understanding systems and evaluating project accomplishments.

Modelling is an important tool for understanding the interactions and dependencies among the various components of natural and human systems. There are few examples, however, of models that link biophysical, cultural and economic elements to provide useful input for policy making. Large-scale mini-models that drive landscape models offer some promise in this respect.

THEME VI: COMMUNICATION

Free flow of information concerning biodiversity promotes and facilitates conservation through discussion, training, exchange, education and extension. Education is an essential pre-condition for constructive changes in our relationship with other human and non-human elements of the global environment. A public educated about biological diversity will appreciate the interdependence between diversity and the welfare of all life forms, be aware of the urgency to protect diversity and value its continuance. This understanding includes the recognition that conservation of biodiversity in the long-term entails conserving dynamic, evolving ecosystems. An environmentally literate public will be prepared to make decisions that result in ecologically sustainable activities.

The long-term objective of environmental education is to nurture environmentally literate world citizens. In particular, we need to target and encourage policy makers on local, regional and national levels to make decisions that will result in actions to conserve biodiversity and embody practices of sustainable development. Recognizing that education is a two-way process, we should promote the use of all means of communication necessary to educate as many people as possible. Local, economically-poor people in biodiversity-rich areas have much to teach to the over-consuming people of more-developed countries.

While there is a growing awareness of the value and vulnerability of the Earth's biodiversity, it is shallow and serves to create a sense of hopelessness. The public requires relevant and comprehensive information that offers greater emphasis on opportunities for positive action to arrest and reverse the decline in biodiversity.

Case Study

Land Use Alternatives for the Amazon

In the Peruvian Amazon, both government institutions and the Federaçion Departmental de Campesinos y Natives de Loreto (FEDECANAL), a rural union, want to protect biodiversity while developing the region. Although both institutions agree that economic, legal and technical incentives should be given to local communities, perceptions of how to pursue larger goals vary. Government institutions treat biodiversity conservation and development as separate goals. They promote agriculture and cattle production while establishing national parks and reserves to protect biodiversity.

FEDECANAL's approach is to promote the diversification of land and resource uses to protect biodiversity and to promote sustainable development in the region. Rural villages, with the help of FEDECANAL, have confronted land use problems by establishing village and inter-village lake or forest reserves. The Mahuizo-cocha inter-village lake reserve of Dos de Mayo, San Cristobal and Nuevo Dos de Mayo is one of many lake and forest reserves that exist in lowland Amazonia. This lake reserve was established in 1967 by residents of the three villages along the Ucayali River. Inter-village regulations control fishing, hunting and timber extraction within the reserve. Due to the enforcement of such rules and local participation these villages are maintaining a large number of fish and animal species within the reserve. They also are preserving overexploited populations of the most valuable fish and game species.

In spite of this successful approach, however, the government's approach appears to be winning. Vast areas of forest land have been converted to agricultural land in the upper Peruvian Amazon. High value timber, fish and game species are overexploited due to an uncontrolled commercial extraction. Clearly, communication and compromise among stakeholders are essential to safeguard the region's biodiversity and potential for sustainable development.

Recommendations

The following recommendations represent long-standing, but still unresolved issues as well as concerns close to the cutting-edge of important subareas, such as policy, management, research and education:

Long-standing unresolved issues

- Human resources (professionals and institutions) devoted to biodiversity conservation must be adequately funded and strengthened through cross-disciplinary training and cooperation at local, national and international levels.
- National and local governments must accept their legal and ethical responsibilities for biodiversity conservation and promote and enforce regulations that protect biodiversity.
- National and international regulation should control exploitation of biodiversity resources so that due and just compensation can be made to countries and communities for the utilization of their biodiversity resources.
- All governments, as an integral part of their national planning policy for sustainable development, should consider the relationships between population size, consumption levels and remaining natural resources, particularly biodiversity.
- In transfering technology, governments and industries should consider the sociopolitical context involved in the transfer to assure the technology is culturally and environmentally appropriate.
- Biological inventories and systematic studies should be increased in critical ecosystems, including linkages to *ex-situ* conservation programs.
- Education regarding biodiversity should emphasize life-long learning and be communicated through both formal and non-formal educational agencies in ways that are both culturally appropriate, sensitive and effective.

Cutting-edge issues

Policies and Management

- Governments should allocate significant long-term funds from national budgets (with a target of >1%) to biodiversity conservation, with particular emphasis on grassroots community participation and consideration of traditional natural resources use models of native peoples.
- All strategies to conserve biodiversity should consider recognition of the rights to land and natural resources of local communities, traditional groups and individuals.
- Valuation of goods and services should include costs of environmental degradation, destruction of biodiversity and depletion of natural resources.
- Efforts to conserve biodiversity should stress the preservation of diverse ecosystems and physical environments, not just single species or genotypes. All nations should consider "endangered ecosystem" legislation.
- National agricultural policies should promote systems management based on applied ecological principles, sustained biodiversity and traditional wisdom, with the goal of producing food crops while enhancing soil fertility and reducing nonrenewable agrochemical inputs.

- Test and promote natural forest management techniques that minimize biodiversity loss and diversify sustainable production of forest products with appropriate economic incentives.
- People who inhabit remaining areas of high biodiversity should have the opportunity to try alternative income generating practices that do not involve the destruction of species habitat. Such practices include aquaculture, the local production of useful bioextracts and artisanal crafts using native and endemic species.
- Evaluate ecotourism as a means of facilitating the conservation of biodiversity and sustainable development for the economic benefit of local communities, where appropriate.

Cross-disciplinary Research

- Describe and quantify resource use systems, including surveys of human dependence on biodiversity resources, historical models, ethnobiological systems and local community participation to assess elements of success and failure in development.
- Initiate long-term field studies, coupled with historical and paleoecological analysis, to evaluate the function and dynamics of critical ecosystems, especially those at low latitudes, to determine the responses of organisms and communities to global change.
- Explore short- and long-term monitoring strategies which combine field inventory techniques with remote sensing for key areas and critical ecosystems at local, regional and global scales.
- Enhance national satellite-based mapping and inventory programs to meet the challenge of providing timely and accurate estimates of remaining tropical forest as the basis for improved management.
- Implement integration of disciplinary knowledge pertinent to conservation and development through cooperative field work, mathematical or descriptive modelling and the use of geographic information systems.
- National and international collaborative programs should be established to prioritize biodiversity and conservation research needs, to fund research and to manage and distribute information produced.

Education and Communications

- *The Message* Personal lifestyle choices made everyday have an impact on biodiversity on many scales. It is essential that this message is conveyed and understood by people of all nations, cultures, ages, education and socio/economic strata.
- *The Target* Both policy and decision makers who interact directly with the environment should be the primary audience. The public at large represents a secondary audience; this group embraces the potential for asserting political pressure and concern.
- *The Messengers* Communication specialists and educators working with biodiversity researchers should step up efforts to develop a set of guiding principles that communicate the important linkages between biodiversity conservation and sustainable development to the educational community as well as to policy and decision makers.
- *The Mechanism* Successful approaches to conservation of biodiversity and sustainable development should be documented and developed into an accessible information bank/network.

CONCLUDING REMARKS

We all depend for our long-term survival on the rich diversity of the Earth's plant and animal life. The complex ecosystems that have evolved in harmony with the world's changing environment are humankind's life support system. Biodiversity extends to all forms of life — from crop plants and domesticated animals to individual wildlife species and ultimately to human beings.

Each element of the surviving global gene pool is irreplaceable over any relevant human time scale. Nevertheless, we are destroying this vast biotic wealth at an alarming and ever-increasing rate. Inappropriate exploitation of resources combines with pollution to drive more and more species to extinction. From the ocean's reefs to the mountain peaks, from the tundra to the tropical forests, life on Earth is under serious threat.

As we degrade and destroy complex ecosystems such as rain forests, we lose increasing numbers of plant and animal species forever. Many species have potential as valuable sources of new food, medicines, natural crop protection agents or simply for their inherent aesthetic qualities. Equally important, this diminishing genetic wealth offers the only available mechanism for adapting to other aspects of global change, including greenhouse warming.

There may still be time to save those wild ecosystems that have survived human impact – but most are found in the under-developed countries of the world where pressure for continuing exploitation is enormous. Long-term conservation here will require huge international commitment on the one hand, and far greater respect for the local people's knowledge and wisdom on the other. It will most certainly demand a right of access to decision-making for all those who have a contribution to make.

Where we already have wreaked havoc on the Earth's surface, we must accelerate the task of restoring biodiversity. Using our understanding of the few undamaged wild lands and successfully-managed ecosystems, we *can* begin rebuilding natural soil fertility, restabilizing eroded mountain slopes, driving back expanding deserts and cleaning up the oceans.

We cannot resurrect extinct species; we can, however, slow the continuing loss of species. If we commit to conserving the rich fragments that still survive, use all our knowledge and inventiveness to reverse the decline, begin the process of restoration and secure the Earth's capacity to adapt to inevitable change, then we can help the Earth recover – but we must start now.

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