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FOURTH WORLD WILDERNESS CONGRESS
WORLDWIDE CONSERVATION

Proceedings of the

SYMPOSIUM ON BIOSPHERE RESERVES

September 11–18, 1987

YMCA of the Rockies
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CONTENTS

EXPERIENCE IN DEVELOPED COUNTRIES

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PREFACE

UNESCO's international network of biosphere reserves is an unprecedented effort to establish a coordinated association of information-sharing areas in each of the world's upland, coastal, and marine biogeographical regions. The lofty purpose of the network is to develop the knowledge, skills, and attitudes needed to integrate conservation and economic uses of ecosystems locally, to serve as hubs for regional cooperation on scientific and educational activites, and to contribute information for addressing multi-regional and global environmental problems. Biosphere reserves provide a flexible paradigm for linking many of the world's outstanding conservation areas, its centers for basic and applied ecosystem research, and its sites for demonstrating sustainable economic uses. They should serve as centers for demonstrating the benefits of synergistic relationships among policymakers, scientists, resource managers, and local people, and for marshalling technical and financial resources from local, national, and international sources to solve problems.

The reality of biosphere reserves is a long way from the goal. Most of the biosphere reserves designated through 1985 were otherwise protected as national parks, nature reserves, experimental research sites, or other types of protected areas. A few have been established as a legal category of protected area in places where no protection previously existed. UNESCO's adoption of the Action Plan for Biosphere Reserves in 1984 dramatically increased emphasis on building functioning biosphere reserves. The plan clarified the conservation, development, and logistic roles of biosphere reserves, and established nine objectives for the international program. Selection criteria focused on designating areas which could fulfill these multiple roles and objectives. The result has been a shift toward designating large areas, often containing complementary sites under different administrators. For the older biosphere reserves, the change in emphasis is fostering consideration of expansions and new institutional arrangements to carry out the roles and objectives.

The symposium is a "window" on the biosphere reserve program as it is being implemented under a wide variety of ecological, social, cultural, economic, and institutional situations. Our objectives have been to provide an overview of the biosphere reserve concept twelve years after UNESCO designated the first biosphere reserves, to demonstrate its remarkable flexibility in adapting to the needs of different nations and regions, and, through case studies of some of the most innovative biosphere reserves, to demonstrate the practical accomplishments on the ground.

We begin with a series of concept papers. Bernd von Droste, Director of UNESCO's Division of Ecology and Executive Director of the UNESCO MAB Secretariat, discusses the increasingly planetary nature of environmental problems and the unique potential of biosphere reserves to develop and integrate information for problem-solving at the local, regional, and global levels. Jane Robertson-Vernhes, Biosphere Reserve and World Heritage Program Coordinator at UNESCO, summarizes the organization and evolution of the biosphere reserve program and its major accomplishments and future goals. Ronald Engel, Professor of Conservation Ethics at Meadville-Lombard Theological Seminary, University of Chicago, then discusses the role of biosphere reserves in building an ethic of resource management and--more importantly from his perspective--an ethic of human community. William Gregg, MAB Coordinator for the National Park Service and

Secretary of the U.S. MAB Project Directorate on Biosphere Reserves, follows with a discussion of wilderness, national parks, and biosphere reserves as complementary, mutually reinforcing concepts. James Thorsell, Executive Officer for the National Parks and Protected Area Commission at IUCN in Switzerland, next discusses the role of biosphere reserves in implementing the World Conservation Strategy. Jerry Franklin of the University of Washington then discusses the role of biosphere reserves as centers for comparative and interdisciplinary research on the structure and function of ecosystems. The general concept papers continue with a discussion of the role of biosphere reserves as centers for developing sustainable production systems by Stanley Krugman, Director of Timber Management Research of the U.S. Forest Service.

The introductory papers conclude with a synthesis by Ariel Lugo, Director of the Institute for Tropical Forestry in Puerto Rico, on the particular role of biosphere reserves as centers for research and demonstration in maintaining and rehabilitating tropical forests.

We turn next to a series of the presentations on coastal and marine biosphere reserves. Carleton Ray and Geraldine McCormick-Ray of the University of Virginia provide an overview of the challenges and opportunities in building biosphere reserves in coastal and marine areas. Sally Hopkins-Murphy of the South Carolina Wildlife and Marine Resources Department follows with a discussion of the first regional coastal biosphere reserve in the United States, which includes the largest river delta on the U.S. east coast and areas under many different administrators. Caroline Rogers of the Virgin Islands National Park and Biosphere Reserve next discusses the situation in the Virgin Islands, where a biosphere reserve is being developed to find ways to integrate conservation and wise use of the reefs, lagoons, and watersheds in an archipelago of small tropical islands that includes the only U.S. national park in a developing region. Finally, Tundi Agardi and James Broadus of the Woods Hole Oceanographic Institute discuss the status of efforts to build biosphere reserves across the U.S.-Canadian border, including the regions of the Maine Archipelago and the great marine banks off New England and Nova Scotia.

Next we follow with experiences and case studies from different regions. We begin with presentations on applications in the technologically sophisticated environment of the developed countries. The role of biosphere reserves in conserving gene pools, monitoring global environmental conditions, and demonstrating the scientific basis for resource management is addressed by Vladimir Sokolov, Peter Gunin, and Yuri Puzachenko of the Institute of Evolutionary Animal Morphology and Ecology (U.S.S.R.). Yuri Izrael and Sergei Semenov of the National Environment and Climate Monitoring Laboratory of the U.S.S.R. State Committee for Hydrometeorology and Control of the Natural Environment follow with a discussion of the background pollution monitoring programs in Soviet biosphere reserves. Bernie Lieff, Superintendent of Waterton Lakes Biosphere Reserve, and George Francis, Chairman of Canada's Working Group on Biosphere Reserves, in two complementary presentations review Canada's considerable success in building biosphere reserves based on the participation of local people, including the particular case of using the biosphere reserve to foster cooperation between a protected area and the adjacent community. John Peine, research director at the Great Smoky Mountains National Park, next discusses the progress of the Southern Appalachian Biosphere Reserve as part of the first "institutionalized" regional MAB program in the United States. James Dawson of the State University of New York at Plattsburgh then describes an ambitious binational proposal to establish the largest biosphere reserve in eastern North America as a linkage of the Adirondack Park in New York and the Lake Champlain Basin, which includes the smallest of the Great Lakes amid territory in both the U.S. and Canada. The case studies are followed by a discussion by Wilson Crumpacker, of the University of Colorado, and William Gregg on developing a national information system on the status of conservation of ecological communities in protected areas greater than 2000 hectares in size.

We then shift to the applications of the biosphere reserve in developing countries, and to the particular role of biosphere reserves in demonstrating principles of sustainable development. Gonzalo Halffter, Chairman of the Mexican National MAB Committee, and Exequiel Ezcurra of The Institute of Ecology discuss the evolution of biosphere reserves in developing countries. They focus attention on the "Mexican model" that relies on cooperation between research institutions and local people in building biosphere reserves, which, in Mexico, are established by government legislation. The overview is followed by case studies from the Sierra de la Laguna in Baja California Sur by Alfredo Ortega and Laura Arriaga of Centro de Investigaciones Biologicas de Baja California Sur; the Sierra de Manantlan Biosphere Reserve, home of the perennial corn (*Zea diploperennis*), by Eduardo Santana, Rafael Guzman, and Enrique Jardel of the University of Guadalajara; from the Sian Ka'an Biosphere Reserve on the Yucatan Peninsula, a center for wetland conservation and traditional Mayan agroforestry, by Enrique Carrillo, Secretary of Education and Popular Culture in the State of Quintana Roo, and Hans Herrman, Director of the Research Center of Quintana Roo.

We turn next to Central America. Brian Houseal of The Nature Conservancy's International Program and Richard Weber of La Asociacion Nacional para la Conservacion de la Naturaleza (Panama) begin with a discussion of the importance of biosphere reserves in maintaining indigenous land use systems and in fostering cultural self-determination of indigenous people. In what was perhaps the inspirational high point of the symposium, the paper includes remarks presented by Aurelio Chiari of the Kuna Tribe and Daniel Castaneda of the Embera Tribe, who tell us of their peoples' enthusiasm for the biosphere reserve concept. Eric Olson of the School of Forestry and Environmental Studies, Yale University, then follows with a brief history of several biosphere reserve projects in Honduras, Costa Rica, and Panama, and an overview of the particular challenges and opportunities each is facing. Hernan Torres, Donald Masterson, and Luis Hurtado of the Tropical Agricultural Research and Training Center (Costa Rica) conclude the series with a discussion of La Amistad Biosphere Reserve as a framework for cooperative planning in a tropical forest ecosystem among areas managed by a variety of agencies for a wide range of purposes.

Finally, Walter Lusigi, Chief Technical Advisor to the UNESCO-Kenya Arid Lands Research Station, directs our attention to the role of biosphere reserves in maintaining and rehabilitating semi-arid marginal lands in east Africa, and points out the advantages of the biosphere reserve approach with respect to traditional protection-oriented approaches to conservation.

The MAB Symposium played to a packed house for four days, reflecting the growing international interest in the role of biosphere reserves as centers for demonstrating the values of conservation. This interest was also shown in the resolution on biosphere reserves warmly endorsed by the Fourth World Wilderness Congress, which we have included in the Appendix to this proceedings. It is our hope that this compendium will foster increased support for biosphere reserves as centers for demonstrating practical approaches for maintaining biological diversity and integrating conservation and development in each of the world's biogeographical regions.

Stanley L. Krugman and William P. Gregg, Jr.

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November 1988

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We would also like to thank John Alexander and Ann Driscoll of the U.S. Information Agency for their help in arranging a tour of U.S. biosphere reserves for participants from overseas; to Rufus Philips and M. Navarrete who ably guided the tour and provided translation assistance when it was needed; to Napier Shelton of the National Park Service's Wildlife and Vegetation Division and Bill Wendt of the International Affairs Division for their help in coordination; to Harvey Fleet and the staff of the NPS Geographic Information Systems Division for demonstrating applications of remote sensing and digital cartography; and to the many biosphere reserve personnel who helped plan and coordinate the orientation sessions and field trips in the biosphere reserves--in particular Dave Mihalic, Assistant Superintendent, Stu Coleman, Chief of Resource Management, and John Peine, Chief of Science at Great Smoky Mountains National Park; Wayne Swank, Project Leader of the Coweeta Hydrological Laboratory; Mike Finley, Superintendent of Everglades National Park, and his secretary, Jesse Brundige, at Everglades National Park; and Jill Baron of the National Park Service's Water Resources Division, who coordinated the visit to the high elevation acid rain research site at Rocky Mountain National Park.

William P. Gregg, Jr. and Stanley L. Krugman
Co-Chairmen of the Symposium on Biosphere Reserves

November 1988

THE ROLE OF BIOSPHERE RESERVES AT A TIME OF INCREASING GLOBALIZATION[1]

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ABSTRACT. The trend towards globalization is affecting perceptions of ecological and environmental problems, as problems of ecological research are increasingly being defined from a global perspective. The Man and Biosphere (MAB) Program of UNESCO attempts to view ecological problems globally while searching for solutions applicable at the national, regional and international levels. Biosphere reserves are representative ecological areas that have been set aside in 70 different countries of the world for conserving genetic resources and promoting international cooperation through ecological research and monitoring of environmental parameters. They are also centers for environmental education and for demonstrating the role of genetic resources for the socioeconomic improvement of local people. Several of the 266 biosphere reserves throughout the world have achieved considerable amounts of success in harmonizing these different functions. These reserves are also becoming the focus for field research on several globally-formulated research questions, both within and outside the framework of MAB.

KEY WORDS: Globalization, UNESCO-MAB Program, biosphere reserves, research, monitoring, conservation, diversity, buffer zone.

In the coming years we can anticipate an unparalleled expansion of ecological research at the local, regional and biospheric scales (see Delcourt, et al. 1983). At the planetary level this is due to the fact that humanity is now perceiving and experiencing a phase of ever-widening globalization--as a result of the complex interdependence between the global economy and the world environment. Clark and Holling (1985) have called the new problems stemming from this interdependence second and third generation concerns of meso- and macro-scales.

These second and third generation concerns are characterized by increasing scale and increasing complexity in terms of the ecological and socioeconomic ramifications of environmental problems. What were local problems of air pollution or desertification are now elevated to the scale of entire continents, such as in the case of acid precipitation, or to the scale of the globe itself, such as in the case of climatic change.

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[1] Address presented in plenary session.

On one hand, the trend towards globalization reflects the concentration of wealth and power within the global exchange economy, which gets its impulses from a few centers of increasing influence. On the other, the trend reflects a vast international grass roots effort to develop new forms of self-help and cross-national cooperation, which by their very nature are decentralized, citizen-oriented and fueled by NGO movements.

Globalization is also the key to our current understanding of environmental processes, where we realize more and more that local phenomena are determined by global interactions. In socioeconomics, too, we see that changes in world markets may have large-scale impacts on land use and resource management, which in turn may have positive or destructive effects on local environments.

There is a need to substantially reform ecological research and conservation because the environmental and resource management issues of today cut across traditional ecosystem boundaries, across social and economic systems, and across political frontiers. In addition, these issues are increasing in scale.

One response to these new challenges in the field of conservation and science is the multifunctional system of biosphere reserves. Biosphere reserves are an international system of protected areas which are included in the Man and the Biosphere Program (MAB) for their value in conservation and in providing the scientific knowledge to support sustainable development. Biosphere reserves, as a network, make up a world-wide system for macro-scale conservation and global scientific research (UNESCO 1987). With the advent of increasing globalization, biosphere reserves are providing new opportunities that complement their important role in resolving local and regional problems.

Indeed, the international biosphere reserve network deals with man/environment interactions at many different spatial and time dimensions, and demonstrates the essential link between conservation and science in meeting societal needs at different levels. These levels occur at the micro-, meso- and macro-scales. The individual biosphere reserve relates to its local community at the local scale; the biogeographical cluster biosphere reserve has a regional dimension; and finally, the international biosphere reserve network as a whole has significance for global science, for the conservation of global biological diversity and for helping to improve human welfare.

The discrete building block of the international biosphere reserve network is the individual biosphere reserve site, which protects within its core zone a minimally disturbed ecosystem--hopefully allowing species to continue their evolution--and which also includes a buffer zone where selected, controlled uses such as traditional land uses, recreation, and experimental research can take place and where human settlements may occur. The transition area or zone of cooperation, which adjoins the buffer zone, is used for demonstrating the application of ecological science to sustainable development, which is a top priority for the MAB Program.

The symposium on biosphere reserves, which forms part of this World Wilderness Congress, has shown the ingenuity with which the biosphere reserve concept can be adapted to specific cultural and socioeconomic environments. The very flexibility of the concept is increasingly attractive to policymakers and planners who wish to accommodate conflicting interests of conservation and development, to ensure relevant scientific progress, and to develop productive and cooperative relations with local people.

A major task of biosphere reserves is to help stem the loss of genetic and biological diversity. Biosphere reserves should be located and managed in a manner that will help to prevent insularization and fragmentation of individual populations, which increase the probability of species extinction and accelerate the process of ecosystem decay which can precipitate biotic collapse (Wilcox 1980).

Biosphere reserves provide a unique framework for exchanging and sharing experiences on basic biological research and technologies for the preservation of biological diversity; for example, in the design and management of core areas and in the compatibility of specific uses in buffer zones. A key subject for conservation research in biosphere reserves is how to manage the entire global system of biosphere reserves to maintain biological diversity while promoting the cultural identity of local people and safeguarding natural integrity to allow ecological processes to continue (Engel 1985). A key question is: How does sustainable development relate to conservation of biological diversity? Massive scientific inputs are required to provide the answer.

Biosphere reserve managers should be concerned with maintaining biological diversity for two reasons:

(a) To preserve unique genetic information; and

(b) To maintain ecosystem integrity. When biological diversity becomes lost at the different levels of biological organization--populations, communities, or ecosystems--there is a decline in resilience and the possibility for an ecosystem to recuperate from stress. Hence the need to maintain the integrity of entire ecosystems.

Biotic resource management in biosphere reserves requires a comprehensive knowledge of their biological resources. Biological inventories are presently being carried out by the Smithsonian Institute in several biosphere reserves in South America, such as Beni (Bolivia) and Manu (Peru) within the MAB/Smithsonian Biological Diversity Program. This program also gives priority to training, and this year about 40 specialists will receive field training in biosphere reserves and at the Smithsonian Institute in Washington.

At the local level, biosphere reserves work most successfully when they obtain the full support from local people who participate in their planning and management. Environmental awareness and education programs are key elements in this process. A recent survey of the 266 biosphere reserves which now exist in 70 countries shows that most of them have environmental education programs; good examples are found at Tayrona (Colombia) and Pilis (Hungary). Furthermore, almost all biosphere reserves have educational programs: Berezinskiy Zapovednik (Byelorussian SSR); Mt. St. Hilaire (Canada) and Montseny (Spain). However, a similar survey for research programs shows that only a small fraction of these programs correspond to the criteria established for MAB interdisciplinary research. Examples for successful research projects demonstrating sustainable development and cooperation with local people are found, for example, at the Trebon Biosphere Reserve in CSSR, at the Omayed Biosphere Reserve in Egypt, in the Cevennes Biosphere Reserve in France, at the Mount Kulal Biosphere Reserve in Kenya, and in the Sian Ka'an and Mapimi Biosphere Reserves of Mexico. It is important to share this experience throughout the biosphere reserve network.

The meso-scale of biosphere reserves can be demonstrated by the example of the Carolinian-South Atlantic Biosphere Reserve in the USA, which is a biogeographical cluster biosphere reserve. This type of biosphere reserve sets up a regional network of disjunct conservation areas and major experimental sites to support development of a conservation and sustainable development strategy for a particular biogeographical province.

These cluster biosphere reserves are established in such a way that they cover ecological gradients within a given biogeographical province, including major ecosystem interfaces and other zones of high biological diversity. From the conservation biology point of view, biogeographical cluster biosphere reserves provide particularly good insurance against uncertainty and surprise in a time of possible global change. This is because large, disjunct and diverse conservation areas are protected under coordinated management at strategic locations. These different elements of a cluster biosphere reserve should be linked to the extent possible through corridors permitting the movement of biota. Obviously, the management of biogeographical cluster biosphere reserves requires an innovative organizational framework allowing the close cooperation of different land owners and agencies. Such cooperation can greatly improve the quality of conservation and science at the regional level through increased interaction and sharing of experience and knowledge between those who otherwise would work separately.

The macro-scale is the highest level of organization for biosphere reserves. Biosphere reserves will ideally cover all 193 terrestrial biogeographical provinces of the world. Today, we are 65% on the way to meet this goal. In their final form, they will constitute an unmatched system of macro-conservation and global science.

Such a planetary network will be more than just an assembly of individual sites. Indeed, we can already anticipate that biosphere reserves will play an important role in global science in the 1990s as a planetary network for observation of global change and more particularly for the interpretation of its causes and prediction of the effects. This has particular reference to ICSU's emerging International Geosphere-Biosphere Program, in which one of the main objectives is to understand the processes that govern the evolution of planet Earth in the time scale of years, to decades and to centuries. The principal source of data will be the earth satellites. The international network of biosphere reserves can provide key locations for research and monitoring and as validation sites for modeling and remote sensing. Thus, a number of biosphere reserves can provide global observatories in bellwether biogeographical zones, such as the tundra-taiga interface, alpine timberlines, savannah/desert edges and flooded lowlands.

A number of biosphere reserves, such as Luquillo in Puerto Rico, which will celebrate 100 years of tropical forest research in 1989; Bialowieza in Poland; and Repetek in the USSR have some of the longest research records available. They provide excellent potential for long-term monitoring since this research has revealed the "background" fluctuations and ecological cycles upon which the more recent global changes are superimposed.

The global network of biosphere reserves constitutes a laboratory for ecologists and other scientists; this potential is hardly exploited. For example, the network lends itself to international comparative studies in biosphere reserves having similar characteristics to test hypotheses in ecological sciences and to develop a better theoretical basis for understanding the repeatability and comparativity of ecological information. Such studies help to make ecology a more predictable and hence a more credible science (di Castri and Hadley 1985).

Four such worldwide comparative studies within MAB are being jointly coordinated with NGO partners, particularly the International Union of Biological Sciences (IUBS). These include:

- Tropical soil biology as a basis of tropical soil fertility;

- Responses of savannahs to stress and disturbance;

- Forest regeneration and ecosystem rehabilitation; and

- The role of ecotones in landscape management.

A fifth theme on human investment and resource use will be examined by MAB in more detail in 1988. Thus, MAB will make a special effort toward linking ecology and economy.

Many challenges still remain ahead for most biosphere reserves. These include:

- Undertaking inventories of biological resources and of traditional uses and technologies;

- Preparation of management plans which reflect the combined objectives of the Action Plan for Biosphere Reserves;

- Training of managers to be "master integrators and motors" of the various cooperative functions of biosphere reserves, which need to be fulfilled locally and internationally (Lusigi 1987);

- Establishment of long-term ecological research projects. In the United States, seven of the National Science Foundation-funded Long Term Ecological Research sites are already included in the biosphere reserve network (Dyer and Crossley 1986);

- Establishment of MAB pilot projects for sustainable development in and around biosphere reserves; and

- Establishment of mechanisms for cooperation with and participation of local people.

In conclusion, the increasing globalization of ecological and socio-economic problems suggests that ecological studies and conservation efforts should be looked at and organized at different scales across ecosystems and beyond ecosystems and more oriented towards societal needs. Both the conservation and ecological sciences have to move up in scale, however, without neglecting the crucial local task of maintaining biological diversity conservation in harmony with sustainable development.

The Biosphere Reserve Concept is pioneering such a harmonious approach. It is advocating an ecological ethic of cooperation, and more importantly, of man's partnership with nature (Engel 1985).

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BIOSPHERE RESERVES:
THE BEGINNINGS, THE PRESENT, AND THE FUTURE CHALLENGES

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ABSTRACT This paper recalls the origins and the objectives of the biosphere reserve concept within the Man and the Biosphere Program of UNESCO. It outlines the ideal biosphere reserve zonation into a central core area, a buffer zone and a transition area. The first years of application of the concept are described, noting that while the numbers of biosphere reserves have increased since 1976 to 266 in 70 countries as of mid-1987, there has been less progress in improving the qualitative aspects. A review of biosphere reserves was made at the First International Biosphere Reserve Congress in 1983, which gave rise to the Action Plan for Biosphere Reserves and to the establishment of the Scientific Advisory Panel for Biosphere Reserves. This latter Panel was able to refine the biosphere reserve concept and establish guidelines for the selection of future reserves, as well as revise the biosphere reserve nomination form. A biosphere reserve survey by means of a questionnaire was launched by the Panel to obtain more information and to identify means for improving the network. Some signs of progress in the application of the biosphere reserve concept are described, including the increasingly important role biosphere reserves are having within the MAB Program. Some challenges for the future are outlined, including making the concept better known, establishing "model" biosphere reserves, making the network really functional, improving the quality of scientific work within biosphere reserves, and strengthening the role of biosphere reserves in conserving biological diversity. Biosphere reserves can thereby offer a means for truly integrating conservation, science and society.

KEY WORDS: biosphere reserves, UNESCO MAB program, conservation, biological diversity.

Introduction

When UNESCO's Man and the Biosphere (MAB) Program was launched in 1971, one of the research themes dealt specifically with the conservation of natural areas and the genetic material they contain. The rationale behind this theme was the need to counter the increasing loss of living species, the lack of scientific knowledge on how to conserve them, as well as the inadequacies of traditional approaches to nature protection. This theme was developed subsequently in 1974 by a task force which drew up a set of objectives and characteristics for special sites, called "biosphere reserves," to identify them with the rest of the MAB Program. The objectives for biosphere reserves, stated in 1974, are as follows (in an updated form):

• To conserve for the present and future use the diversity and integrity of biotic commumities of plants and animals within natural and semi-natural ecosystems, and to safeguard the genetic diversity of species on which their continuing evolution depends;

• To provide areas for ecological and environmental research, including baseline studies, both within and adjacent to such reserves; and

• To provide facilities for education and training.

The emphasis on combining multiple functions within a single given site and on linking these sites into an international network based on a common understanding of scientific purpose made the biosphere reserve concept different from other more conventional means of establishing protected areas. Also, at that time biosphere reserves were unusual as protected areas in that man and human activities were considered to have a constructive role in environmental protection, and in that, vice versa, the biosphere reserve was to contribute to the development of its region. Figure 1 shows the conceptual combination of the different concerns of a biosphere reserve: it is the harmonious, synergistic combination of these which makes the biosphere reserve.

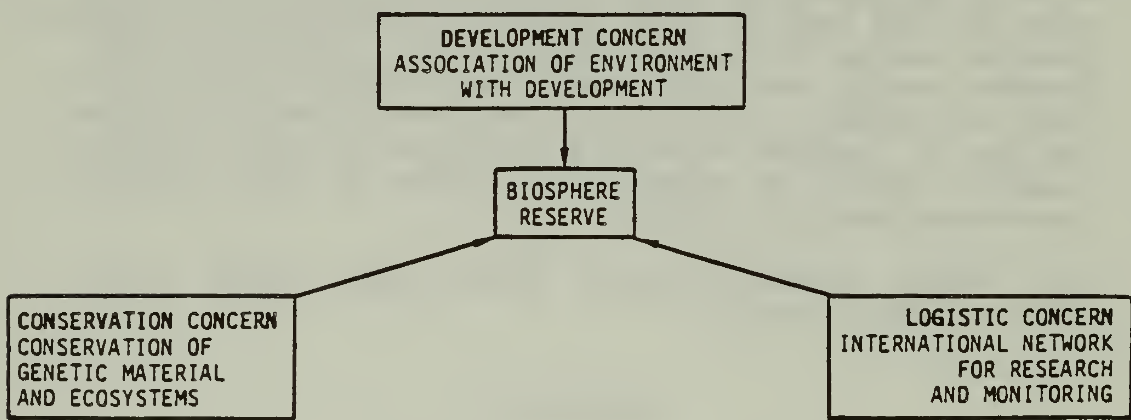

Figure 1.

Organization of a Biosphere Reserve

The different interests of a biosphere reserve are combined by a system of zonation which was developed by the task force in 1974 (UNESCO 1974). This zonation is given, in an updated form, in Figure 2.

Basically, the ideal biosphere reserve concept is organized in three more-or-less concentric zones which can be summarized as follows (UNESCO 1987a):

The core area consists of examples of minimally disturbed ecosystems characteristic of one of the world's terrestrial or coastal/marine regions. A core area has secure legal protection, for example, as a strict nature reserve. Only non-destructive activities that do not adversely affect natural ecosystem processes are allowed. Although natural processes normally operate unimpeded by human intervention, active human intervention, such as prescribed fire or controlled grazing, may be needed in certain subclimax ecosystems to maintain the natural characteristics of the site.

The second zone, the buffer zone, adjoins or surrounds the core area; its limits are legally set out and usually correspond with the outer limits of a protected area such as a national park. Here, the activities are diverse and are coordinated in such a fashion that they help to buffer the core from any harmful outside disturbance. These activities serve the multiple objectives of the biosphere reserve and can include basic and applied research, environmental monitoring, traditional land use, recreation and tourism, general environmental education, and specialist training.

The outermost part of a biosphere reserve is the transition area, which usually is not demarcated but corresponds to a dynamic, ever-expanding cooperation zone where the work of the biosphere reserve is applied directly to the needs of the local communities in the region. Thus, the transiton zone may contain settlements, fields, pastures, forests and other economic activities which are in harmony with the natural environment and the biosphere reserve. This zone of cooperation is particularly useful in helping the biosphere reserve to integrate into the planning process of its surrounding region. In other words, the protected area of the core and the buffer participate through the transition/ cooperation area in the development of the region to which they belong.

The First Years

The biosphere reserve concept was first introduced in 1974, notably through the publication of the report of the 1974 Task Force (UNESCO 1974) and its endorsement by the International Coordinating Council of the Man and the Biosphere Program. MAB National Committees were invited to propose sites for international recognition as biosphere reserves. It should perhaps be reiterated at this point that countries retain full sovereignty over their biosphere reserves and that the biosphere reserve designation implies willingness to participate in the international MAB Program. The biosphere reserve nomination procedure was originally designed to be as uncumbersome as possible in order to encourage wide participation in the biosphere reserve project. MAB National Committees were invited to nominate sites which they considered met the criteria set out by the 1974 Task Force, by filling out a form provided by the MAB Secretariat. MAB National Committees were also asked to refer to the Classification of the World's Biogeographical Provinces prepared specifically by N. Udvardy for IUCN and MAB in an

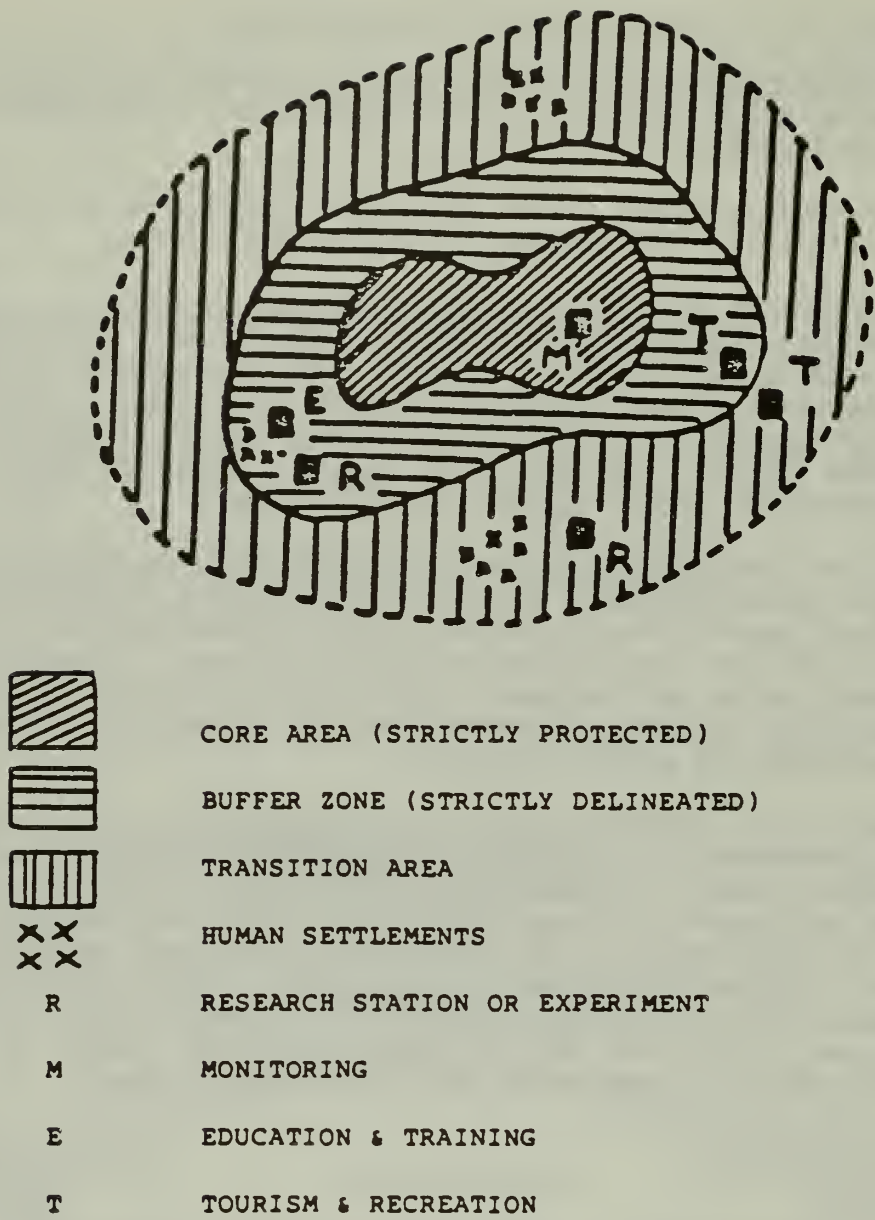

Figure 2. Schematic zonation of a biosphere reserve.

In this zonation, already proposed in 1974, the core area is strictly protected. The buffer zone (formerly called "inner buffer zone") can be used for regulated non-destructive activities and is strictly delineated. A national park normally corresponds to a core area together with a buffer zone of this type. The transition area (which was originally called "outer buffer zone") covers other functions of the biosphere reserve, including experimental research, traditional use, rehabilitation, etc., and it extends to form an area of cooperation in the biosphere reserve.

attempt to define geographical areas for conservation purposes (Udvardy 1975). The ultimate aim was to establish biosphere reserves which should represent all of the biogeographical privinces. Using these documents as guidelines, MAB National Committees prepared biosphere reserve nominations which were subsequently submitted for approval by the Bureau of the International Coordination Council. If the site was accepted, a special biosphere reserve certificate and an official letter of designation, signed by the Director General of UNESCO, were prepared for the MAB National Committee of the country concerned.

It was in this manner that the first sites were designated in 1976; the progression in the number of biosphere reserves is presented graphically in Figure 3. Here it can be seen that as of mid-1987, there were 266 biosphere reserves located in 70 countries around the world, covering about two-thirds of the 193 biogeographical provinces identified by the Udvardy classification system.

Quality versus Quantity

But what about the quality of these biosphere reserves? There has been a gradual evolution in the biosphere reserve concept and its application over the years, which gives an insight into the perception of the biosphere reserve concept and the evolution of the MAB Program in general.

One of the first assessments of the way in which the international biosphere reserve network was being constructed was made by Francesco di Castri and Lloyd Loope in 1977 (di Castri and Loope 1977). Their findings showed, quite understandably, that the biosphere reserve concept was being applied in very different ways in different countries, such that there was a gradient of sites, ranging from large, remote, sometimes uninhabited sites highly suitable for conservation but with little research or active management, to smaller areas with well-established research activities. In consequence, a pragmatic, flexible approach was considered to be the best means to continue to develop the network. A subsequent study by di Castri and Robertson (1981) confirmed the sectoral manner in which the biosphere reserve concept had been applied, and recognized that in only a few cases had the biosphere reserve designation led to an increase in interest in involving local people and in promoting rural development. Another study in 1981, by Goodier and Jeffers (1981), confirmed some criticisms of the growing number of biosphere reserves, stating that they were mostly national parks or nature reserves onto which the label "biosphere reserve" had been attached, with little attempt to integrate the different biosphere reserve functions or to link up the sites into a network through the exchange of information and personnel. All of these studies showed, however, that the potential for a real international biosphere reserve network was present and should be encouraged.

In 1981, the MAB International Coordinating Council made a series of recommendations aimed at improving both the quantitative and qualitative aspects of the international biosphere reserve network. Quantitatively, there was a need to obtain better representation of biosphere reserves in arid and semi-arid areas, in the higher latitudes, in tropical humid forests and in coastal areas, as well as in the "Vavivlov" centers of diversity. Since that time, there have been several additions to the network covering such areas; examples include the Tassili N'Ajjer Biosphere Reserve in southern Algeria, the Lake Torne area in northern Sweden, and the Beni Biosphere Reserve in the

BIOSPHERE RESERVE DESIGNATION BY YEAR

YEAR	NUMBER APPROVED	TOTAL	NEW COUNTRIES	TOTAL OF COUNTRIES
1976	59	59	8	8
1977	72	131	22	30
1978	13	144	4	34
1979	32	176	10	44
1980	15	191	4	48
1981	17	208	7	55
1982	6	214	3	58
1983	18	226	4	62
1984 1985	17	243	3	65
1986	18	261	5	70
1987	5	266	-	70

Figure 3.

upper Amazon basin in Bolivia. Also in 1981, the term "biosphere reserve" came into question since it had negative connotations for a number of people. However, it was felt that the term should be maintained to avoid confusion and the phrase "representative ecological area" was introduced as a sub-title (UNESCO 1981).

The main effort to review biosphere reserves was made in 1983 through the First International Biosphere Reserve Congress held in Minsk (Byelorussia, USSR). This congress gave an opportunity to review the experience with biosphere reserves since 1974 and to lay down guidelines for the development of the international biosphere reserve network in the future (UNESCO-UNEP 1984). On the basis of the work of this congress, the Action Plan for Biosphere Reserves was elaborated, setting out 35 actions, grouped under 9 objectives, aimed at governments and relevant international organizations in order that they develop the multiple functions of biosphere reserves within the overall context of MAB (UNESCO 1984). Thus, the Action Plan spelled out the types of actions that could be taken by individual biosphere reserve managers and by MAB National Committees in truly implementing the concept in an integrated fashion. This Action Plan for Biosphere Reserves was adopted by the MAB International Coordinating Council in December 1984 and subsequently endorsed by the international organizations which are MAB's main partners in its implemenation, namely UNEP, FAO and IUCN.

The Work of the Scientific Advisory Panel for Biosphere Reserves

One of the actions of the Plan foresaw the establishment of a Scientific Advisory Panel for Biosphere Reserves to ". . . refine criteria for the selection and management of biosphere reserves, to evaluate proposals for new biosphere reserves and to review from time to time the effectiveness of the network." This panel met twice, in Cancun (Mexico) in September 1985 and in La Paz (Bolivia) in August 1986 (UNESCO 1987b).

The Scientific Advisory Panel for Biosphere Reserves was able to make a more comprehensive study of the reality of existing biosphere reserves and do some intellectual "homework" on the biosphere reserve concept and how it can and should be applied.

The panel was able to focus the relatively "hazy" biosphere reserve concept in sharpening the three main concerns outlined above and their harmonization in a biosphere reserve; this process of focusing is described by Batisse (1986). The panel recognized that the biosphere reserve concept had recently shifted in emphasis towards increased involvement with local people and their development needs. As a result, the panel considered that biosphere reserves should be viewed as "demonstration sites of harmonious, long-lasting relationships between man and the natural environment" (UNESCO 1987b). The upsurge in interest in the contribution of biosphere reserves to sustainable development is indicated in the papers by Francis (1985) and von Droste and Gregg (1985). It is interesting to note that his shift in emphasis comes in parallel to that of the MAB Program proper, where it is now recognized that MAB looks at man in the biosphere as an integral part (see UNESCO 1986a).

With this analysis as a background, the panel was able to prepare a revised set of guidelines for the selection of biosphere reserves (and not "criteria" *per se*) which were subsequently approved by the Bureau of the International Coordinating Council in March 1987 (UNESCO 1987c). A revised nomination form, designed to help MAB National

Committees nominate truly worthy sites as bisphere reserves, was also drafted by the panel and endorsed by the MAB Bureau. Both of these documents have been finalized and widely distributed.

The panel also made a preliminary review of the existing international biosphere reserve network, but realized that there were considerable differences in the amount of up-to-date information available for all. In order to mitigate the situation, the panel launched, in June 1986, a biosphere reserve survey based on a questionnaire. This questionnaire was designed with serveral objectives in mind: on the one hand, it aims to obtain more information on the status of each biosphere reserve for incorporation in the MAB Information System (UNESCO 1986b); on the other, it provides MAB National Committees and biosphere reserve managers with a tool for making a self-appraisal of their own biosphere reserves and thereby to stimulate taking measures for their improvement; it gives an objective assessment of the status of the international biosphere reserve network and hence highlights the topics requiring special attention in the implementation of the Action Plan for Biosphere Reserves. In addition, the survey gives a mechanism for "filtering" the list of biosphere reserves: those that reply and show that efforts are really being made along the lines of the Action Plan for Biosphere Reserves can eventually become "models" or "illustrative examples" of the biosphere reserve concept in practice. Those biosphere reserves that do not reply to the survey can be considered as not contributing to the international network and could eventually be deleted by their MAB National Committees (UNESCO 1987c). This survey is currently being completed; to date (September 1987), some 182 biosphere reserves out of a total of 266 (i.e., 68%) in 47 countries (out of 70) have replied. The final results will be made known to all MAB National Committees and biosphere reserve managers.

The Scientific Advisory Panel on Biosphere Reserves was dissolved by the MAB Council in 1986 but may eventually be reconstituted to review the progress of the Action Plan. The MAB Council decided, however, that the work on the biosphere reserve concept should be continued for topics of specific interest, such as the application of the concept in coastal marine areas, the interrelationship between biosphere reserves and the geosphere-biosphere observatories for global change, or the role of biosphere reserves in conserving biological diversity (UNESCO 1986a).

Signs of Progress in Strengthening the Biosphere Reserve Network

A preliminary study of the responses to the biosphere reserve survey described above not only confirms the weaker points already perceived in earlier studies, but also gives a clear indication of the efforts that are now being made by a number of MAB National Committees to improve their biosphere reserves. This indication is substantiated by the high quality of biosphere reserve nominations that have been submitted by MAB National Committees since the launching of the Action Plan in 1984. In these cases, the biosphere reserve concept has been applied with considerable imagination; a good example is the "cultural-natural" biosphere reserve of Costero del Sur in Argentina, where the people of the municipality of Magdalena are using the concept as a tool for land use planning to conserve local natural and cultural resources. Other examples include the Dutch Waddensea (soon to be complemented by a contiguous area in the Federal Republic of Germany), the Tzentralnosibirskii reserve in Siberia in the USSR, and the innovative coastal marine cluster of the Carolinian-South Atlantic biosphere reserve in the United

States. Also, an increasing number of university theses are being undertaken on the theme of biosphere reserves or with biosphere reserves as being the site of research. Training courses for young scientists or for recycling of specialists are being conducted more and more within biosphere reserves, for example in Sinharaja Biosphere Reserve in Sri Lanka, or in the Waza Biosphere Reserve in Cameroun (von Droste 1986).

In parallel, there is also an indication that biosphere reserves are gradually starting to play a key role in the development of the MAB Program.

As has been stated above, in the orginal formulation of the biosphere reserve concept, there was the idea the biosphere reserves should serve as a locus, or logistic base, for national MAB activities under the other project areas of the scientific program. A chronological account of the development of this "logistic" concern of biosphere reserves is given by Batisse (1986).

In recent years, there has been an increase in interest in biosphere reserves in fulfilling this logistic role. Indeed, one of the first actions that new MAB National Committees is encouraged to do is to consider establishing a biosphere reserve to act as a geographical focus for future work contributing to the MAB Program. At the present time, this is the case, for example, for Madagascar and for Vietnam. Some scientists go so far as to suggest that biosphere reserves are the most important contribution that the MAB Program has made to the integration of the natural and social sciences. Some have even predicted that biosphere reserves shall continue long after the program itself is over (Slatyer 1981; Halffter 1987). The reasons for such opinions can be analyzed as follows (Robertson Vernhes, in press):

- Biosphere reserves cut across and interconnect the various themes of the program, since they can become the sites for MAB comparative studies or MAB pilot projects, whether for studying the basic structure and function of tropical humid forests, the restoration (or redevelopment) of grazing lands, the sustainable development of island systems, or the use or preception by urban populations of green space. This role of biosphere reserves as a "master integrator" has been, in particular, described by von Droste and Gregg (1985).

- Biosphere reserves by their definition contain core areas which have national legal protection and therefore benefit from longer term security. This long term conservation mission of biosphere reserves enhances their value, since they offer sites where scientific data can be accumulated over time and where background observations can be made to act as references or controls for comparison with other areas. This particular feature of biosphere reserves has been described, for example, by di Castri and Hadley (1984) for comparative ecological research; by Sokolov (1985) with respect to monitoring; and by Dyer and Crossley (1986) with respect to remote sensing. This characteristic is also of interest to the recently launched International Geosphere-Biosphere Program, in which the concept of geosphere-biosphere observatories will be developed to measure global change (ICSU 1986).

- Biosphere reserves offer a "humanistic" approach to nature conservation in a manner such that plants and animals are not *a priori* considered more important than man. On the contrary, man is considered as a positive, key factor in the maintenance of a given biosphere reserve; in return, man can learn how to live in harmony with his cultural and natural environment. This more anthropocentric, ethical or spiritual viewpoint of biosphere reserves has been described, for example, by Halffter (1981, 1985), Gregg and McGean (1985), and Engel (1985). This latter author has equated biosphere reserves with "sacred spaces" which are needed to "reorient contemporary society to the natural world."

The Challenges for Biosphere Reserves for the Future

The biosphere reserve concept is a relatively "young" approach to nature conservation in that it was elaborated only some 13 years ago, and only in recent years has it been applied successfully in the field. The Action Plan for Biosphere Reserves was designed to improve both the quality and the quantity of biosphere reserves and to link them together in a real network. It should be recognized that it takes time for people to learn about the biosphere reserve concept and then introduce the changes to apply it in the real world, which itself requires initiative, tenacity and very often a good sense of psychology! Hence, a great deal of work remains to be done to implement the Action Plan and thereby to move definitively away from the conceptual stage of biosphere reserves and into the real world. MAB National Committees, individual scientists, and, above all, the managers of existing biosphere reserves, have this responsibility, with advice and coordination, as necessary, from the MAB Secretariat. Some of major challenges which they will have to face in the future are as follows:

• Make the biosphere reserve concept better known. The term "biosphere reserve" is inadequately known both to scientists and to the general public. As the majority of biosphere reserves are centered on an already existing protected area, the additional designation can cause confusion unless it is well explained during the establishment process (see, for example, Sankhala 1987). Indeed, Kellert (1986) stated that ". . . the potential value of the biosphere reserve concept may flounder unless a far more ambitious and successful effort is made to enhance public appreciation and understanding . . ." On the international level, efforts are underway to mitigate this situation, for example, by the preparation of a brochure explaining what biosphere reserves are, written in easily understood language for general distribution, and the preparation of video films covering selected biosphere reserves. The opportunities for national and local initiatives for biosphere reserves must be actively exploited.

• Make biosphere reserves really work as biosphere reserves. This challenge can be addressed in several ways. MAB National Committees are encouraged to set up a national strategy for implementing the Action Plan for Biosphere Reserves, based on concrete measures which can be taken to build on the strengths and to mitigate the weaknesses of existing reserves and/or to identify suitable sites which have the potential to become good biosphere reserves. Such national strategies for biosphere reserves are precisely the type of strategy mentioned for "non-convention" protected areas by the World Commission on Environment and Development (WCED 1987). Examples of national strategies for biosphere reserves are under preparation in Canada and the United Kingdom. Also, a limited number of functional biosphere reserves should be selected and strengthened in order that they become "models" or "illustrative examples" of how the biosphere reserve concept can be put into action. Large countries could select one or two; smaller countries would need to consult by region as to which site would become the "model" for the biogeographical province--this line is already being followed in the Mediterranean region. Another means is to recycle the managers of biosphere reserves to help them better understand the concept and their role in its application. In parallel, biosphere reserve managers should be given special recognition, for example, through national identification of their profession, and through an international association of biosphere reserve managers.

• Make the biosphere reserve network really functional. Although it can be said that there are currently 266 biosphere reserves located in 70 countries, at the present time these essentially correspond to 266 separate dots on a map. The challenge lies in making the necessary information links to join these dots into a functional network which can promote the exchanges of scientists and management personnel to learn from the experience of other biosphere reserves, particularly in their quest for integrating conservation with local needs and socioeconomic development. The international biosphere reserve network has an extremely important role to play in fostering the type of sustainable development which is embodied in the World Conservation Stategy (IUCN 1980).

• Improve the quality and quantity of scientific work in biosphere reserves. At present, the research reported for the majority of biosphere reserves tends to be sectoral in nature. Efforts need to be directed to use biosphere reserves as the host sites for comparative ecological studies as described by di Castri and Hadley (1984) or of MAB or "MAB-type" pilot projects directed at specific problems such as desertification, or for monitoring studies, such as will be promoted under the International Geosphere-Biosphere Program (ICSU 1986). Also, biosphere reserves should contribute more to the advancement and the application of conservation biology. The research program for biosphere reserves should therefore try to strike a balance between the basic and applied research needed to resolve local resource problems and the research and monitoring contribution to global programs.

• Strengthen the role of biosphere reserves in conserving biological diversity. The conservation of genetic material *in situ* is a major leitmotiv for biosphere reserves: the increase in interest to conserve biological diversity in general has recently been highlighted in the report of the World Commission on Environment and Development (1987). It is recalled that IUCN lists about 3,500 protected areas, of which 266 are currently also biosphere reserves (IUCN 1985). In terms of protected land area, therefore, biosphere reserves by themselves can only contribute to the world's "store" of diversity and its conservation *in situ*. However, biosphere reserves are selected for their possibilities for demonstrating wise land use; restoration of degraded ecosystems; harmonious, traditional land use; and alternative, "nature friendly" means of rural development which help maintain and can even enhance the natural heritage. The potential that biosphere reserves offer in conserving biological diversity in the areas outside protected areas is therefore very great indeed. In short, biosphere reserves have the potential of generating the knowledge and the skills to use natural resources in a manner which will allow the conservation of biological diversity on a global scale.

Conclusion

The biosphere reserve concept has been put into practice for over ten years. In this relatively short time period, the concept has become more finely tuned and yet has remained flexible and adaptable to the vast array of habitat and ecosystem types, human contexts and economic situations that make up the planet. The potential of biosphere reserves to generate information and skills for using natural resources in an ecologically sound manner and hence to contribute to rural development and to conserving biological diversity is considerable and has yet to be fully exploited. In other words, biosphere reserves are not "just another category of protected area." With imagination and conviction, they offer a beginning in truly integrating conservation, science and society.

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THE SYMBOLIC AND ETHICAL DIMENSIONS OF THE BIOSPHERE RESERVE CONCEPT

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ABSTRACT. The biosphere reserve concept is a comprehensive ideal of planetary co-evolution. In order for this potential to be realized, the concept must be expressed in adequate symbolic and moral languages. Two kinds of value-laden language are found to be present in the biosphere reserve literature--resource management and community. Each is analyzed in terms of its basic symbolic and ethical dimensions and evaluated in terms of its capacity to express the fundamental vision of the biosphere reserves and provide moral guidance for conservation efforts in the contemporary global situation. It is concluded that the moral language of community is the most authentic basis for expressing the symbolism and ethics of the biosphere reserve concept, and it is recommended that this priority be made explicit.

KEY WORDS: Biosphere reserve, values, symbolism, ethics, sacred space, co-evolution, ecology, resource management, community, globalization, sustainable development.

Introduction

One of the refreshing aspects of the Man and the Biosphere Program is its recognition of the role of values in science and conservation. A shared concern for the fate of the Earth is a solid foundation for inter-disciplinary discussion. If those of us who are professionally involved in the field of ethics have a special role to play, it is to help make explicit the values that are already implicit in all aspects of conservation work, and to provide critical tools of thought that will better enable the world's citizens, lay and expert, to exercise their inherent capacities for moral discernment and decision.

Implicit in the biosphere reserve concept are values of far-reaching import for the future of our species and the planet. They are, in my view, the values necessary to save humanity from its present course of environmental and social destruction. However, the concept needs an adequate symbolic and moral language to communicate these values if it is to marshall public support and fulfill its promise as a guide for international conservation efforts.

A review of the literature on biosphere reserves reveals a basic ambiguity. There are two value-laden languages competing with one another: the language of resource management, which is dominant, and the language of ecological community. I will argue that the second is more powerful and significant, and if creatively articulated, has the capacity both to communicate to the public the intrinsic vision of biosphere reserves and to serve as a guide through the global moral dilemmas that face the conservation movement.

It so happens that I first heard about MAB and biosphere reserves in 1983 at a time when I had just finished a prolonged study of the struggle to preserve the Indiana Dunes--the reputed "birthplace of the science of ecology" in the United States (Engel 1983). In the course of this study I learned how a vision of a special or "sacred" landscape could function both descriptively, as an explanatory model for seminal research in the ecological and other sciences, and prescriptively, as an ideal model for social action and cultural identity in the larger society.

The Dunes vision integrated scientific, social, esthetic, and religious perceptions of fact and value in one master image. And it motivated persons to preserve the unique landscape that was the tangible embodiment of its unifying vision.

But it was a flawed model, as ultimately the Indiana Dunes National Lakeshore is a flawed reality. Why? Because the synthetic vision of the Dunes, on the basis of which this remarkable integration had occurred, was not itself adequately unified. Primarily a model of small groups of individuals living cooperatively with one another and with the cooperative processes of the native landscape, it neglected complex human institutions, especially those of an economic and political character. Thus it perpetuated the dualism of Western culture--simple village life in harmony with nature and complex competitive urban life in conflict with nature. The result: one of largest industrial regions of the world in contiguous conflict with one of a nation's most valued landscapes.

What attracted me immediately in the article about the biosphere reserve concept (Gregg 1983) was that here was an idealized landscape vision that was thoroughly ecological from the beginning. Like the Dunes vision, it was simultaneously descriptive and prescriptive--that is to say, it was a model in terms of which persons could productively study what is, and at the same time work on behalf of what ideally ought to be. But unlike the Dunes vision, the MAB vision appeared to include from the start the full range of human and natural processes. It was an ideal model of the co-evolution of humanity and nature.

Think of the spatial configuration of the typical or representative biosphere reserve (Batisse 1986; Gregg and McGean 1985). Can we wonder why this concept has attracted such commitment? Can we imagine a better model for how to study the co-evolution of humanity and the rest of nature and at the same time envisage how it ought to proceed in the future? Can we imagine a better sacred geography for our vision of human ecology? A more fitting way to unify the wild and humane?

The core area assures that the evolution of life will continue in each ecoystem of the biosphere without human disruption. It also permits ongoing studies of the natural evolutionary processes in which we participate and to which we must adapt if we are to survive. The buffer zone preserves traditional economies and societies that have proven their capacity to sustain themselves over many generations, and at the same time experiments with new technologies and ways of life that will improve the capacity of the social and cultural heritage to adapt and survive in the future. The transition area encourages the surrounding society to learn from, and eventually to emulate, the reserve. In effect, the ideal biosphere reserve serves as a wellspring for the ecological and social preservation and renewal of the biosphere.

This initial reading of the biosphere reserve model was confirmed during my subsequent sabbatical trip in 1984, especially when I visited the Cevennes Biosphere Reserve in southern France, recently employed by Batisse as a model for the system as a whole (Batisse 1986, Engel 1985a). This particular reserve is so structured that almost every vista includes both a core area, where natural evolution continues uninterrupted and human beings are essentially visitors, and a glimpse of a town or farm where people are seeking to live in balance with the land. When the literature of the biosphere reserves speaks of the "human ecosystem" as the ultimate unit of scientific accountability, it is this kind of holistic landscape that is concretely meant.

My conclusion then and now is that the reserves are potentially about the work of creating a new kind of sacred space in which human beings deliberately take moral responsibility for the co-evolution of our species and the Earth, and that, if completed in such a way as to embrace urban as well as wild and rural landscapes, the biosphere reserve system could represent in microcosm, at local, regional and planetary levels, as perfect a model of the biosphere conceived as a cooperative unity of human civilization interacting with the rest of nature as it is possible in our epoch to achieve.

This is the potential of the biosphere reserve concept. That potential can only be actualized, however, if the ideal is communicated through adequate symbols and moral norms; in other words, through value-laden language that (1) truly expresses its inherent vision, and (2) provides guidance for how to resolve the moral dilemmas human beings now face regarding their right relationship to one another and to the Earth. Unless the biosphere reserve concept is articulated in words and images that have integrity and speak with power, it will never marshall sufficient public support and commitment to succeed.

The Two Languages of the Biosphere Reserve Literature

A careful reading of the biosphere reserve literature discloses two principal constellations of symbols and moral norms in terms of which the concept is currently being defined. We may call these the "language of resource management" and the "language of community." These two distinct ways of thematizing the values of humanity's relationship to the rest of nature may be traced to the beginnings of the conservation movement (O'Riordan 1981).

The most prominent way in which the biosphere reserve concept is interpreted is through the language of resource management. This language permeates the literature of the biosphere reserves, as well as most United Nations and national government agencies concerned for the environment. It is evident in such ubiquitous terms as "management," "objectives," "systems," "strategies," "resource utilization," "production," "projects," "sustainable," "control."

The basic image of this language is the management of nature as a "resource" or "means" for sustainable human economic development. The moral imperative is the advancement of human material well-being--or, as Gifford Pinchot, first Director of the United States Forest Service, worded it, "the greatest good for the greatest number for the longest time"--through efficient, prudent, "objectively" scientific management practices. The Bruntland Commission sees hope for the future if we "begin managing environmental resources to ensure both sustainable human progress and human survival" (World Commission on Environment and Development, 1987).

In the biosphere reserve literature, the image of human progress through responsible management functions in close association with the image of the biosphere as a "human life support system." The environment is not referred to as a value in its own right, but only instrumentally, as it serves human needs and purposes. There is the implicit value assumption that human beings, now the dominant species, have the technical capacity to understand and control the course of natural evolution. The exclusive reason for biological conservation is human interest satisfaction.

The second constellation of symbols and moral norms, which focuses on the image of community, is also present in the biosphere reserve literature, but at deeper and often more hidden levels of meaning. At times the language of community is quite visible, for example, in the literature of the Cevennes Biosphere Reserve cited by Michel Batisse as an unusually fine example of the basic meaning of the biosphere reserve concept. It is also visible in essays that interpret the meaning of the biosphere reserves from the perspective of developing countries. This literature typically stresses the importance of representating local communities in decisions that affect the reserves, the equitable sharing of benefits by local communities, and the integration of cultures and bioregions (Halffter 1981; Lusigi 1981). Santana, Guzman and Jardel (1988) argue that the success of a reserve might depend more on the successful establishment of coordinating groups than on "technical solutions to environmental problems." Sometimes the symbolism of community creeps in unawares: "Successful biosphere reserves constitute models of the harmonious marriage of conservation and development" (Batisse 1986, emphasis added).

By the language of community I mean language that is woven out of the root metaphor of belonging. It is the language of diverse individuals participating in the creation of social relationships, whose values are shared by all. Such language can be used for human, non-human, and "mixed" societies, as when we speak of world "citizenship," "respect" for nature, or the world as our common "home." The constellation of symbols and moral norms associated with community lifts up ideas of kinship, communication, intrinsic worth, dialogue, equality, hospitality and compassion.

In this language, participation rather than management is the morally requisite modality for intervention in natural and cultural systems. As Francesco Di Castri (1981) writes:

> . . . ecology has begun to take into consideration the intangible and non-quantifiable elements of human activity and thought--the different perceptions which populations and individuals have of development and of the quality of life, their aspirations and their feelings of belonging and of accomplishment . . . "participation" has become the key concept in the new generation of MAB activities--participation of the local population at the outset when research priorities are planned, participation of the various disciplines of the natural and human sciences, and participation of decision-makers and planners.

To make participation rather than management the fundamental theme of MAB requires the development of new forms of interdisciplinary research and development that are holistic and community-regarding. William Gregg (1988) makes a similar point when he argues in his paper for this symposium that conservation depends on our capacity "to demonstrate the interdependency between the material, social, cultural and spiritual dimensions of human existence and the maintenance of the planet's biological diversity."

What I am here calling the language of community may be identified with what is called the "communitarian" tradition in ethical theory, presently the subject of increased attention by political and environmental ethicists alike (Sandel 1984; Caldicott 1987). This tradition takes the notion of the "common good" as the center of ethical reflection and grounds ethical obligation in our participation in norms, such as cooperation, embodied in communities and implicit in their ways of life. Current "eco-centric" or life-centered interpretations of environmental ethics, such as deep ecology, follow this ethical logic and apply it to to all communities of living organisms, inclusive of human beings (Norton 1986).

One way to contrast the two moral frameworks of resource conservation and community is to compare the meanings each gives to cooperation. There is general consensus that cooperation is one of the key symbols of the biosphere reserve concept. "Cooperation not only serves as the master integrator of the other functions, but also provides the moral force behind the biosphere reserve concept . . . it is an essential part of the symbolism, and a key factor in fostering personal commitment on the part of growing numbers of people" (UNESCO-MAB 1984). However, it makes a considerable difference whether "cooperation" is part of the constellation of symbols associated with the language of resource conservation or with those of the language of community. Cooperation in the language of resources means persons working together to use the environment to produce goods for human use and consumption. Cooperation in the language of community means nurturing mutually enhancing relationships with all persons and organisms with which one shares the interdependent web of life.

It is important to emphasize that resource conservation symbolism and morality must always be an important part of the biosphere reserve concept. Use-values are legitimate, necessary aspects of our relationship to the natural world and modeling sustainable use is an urgent and essential part of the mission of biosphere reserves. The responsible exercise of instrumental or technical reason by human societies is essential to sustain not only the economic, but the social, political and spiritual dimensions of human life as well as the survival of the biosphere itself.

However, technical reason is principally concerned for <u>means</u>, not <u>ends</u>, and we face serious problems when we use the language of resource conservation as the <u>primary</u> rather than <u>secondary</u> framework for defining the essential meaning of the biosphere reserve concept. The production of goods for human use and consumption, as important as it is, finds its final meaning and purpose not in itself but in its contribution to the well-being of the human community in all its dimensions, and ultimately, its contribution to the total community of life. The constellation of symbols and moral norms associated with resource conservation does not do justice to the biosphere reserve concept's full-bodied holistic vision of co-evolution. Furthermore, as we shall see in the next section, because it is concerned exclusively with means, it may be placed inadvertently in the service of ends that are antithetical to the protection of the integrity of the reserves themselves.

I believe a plausible argument can be made that it is the moral language of community that most authentically expresses the symbolism and ethics of the biosphere reserve concept. Approached through the moral language of community, one of the basic symbols of the biosphere reserve concept, global evolution, becomes a mosaic of co-evolving, self-governing communities consisting of diverse forms of life, with intricately balanced, interdependent parts and processes. The human species, while dominant, is only one part of this mosaic, a part which, if it is to survive and flourish, must grow in practical wisdom about how to overcome its alienation and belong again to its environment.

The language of community--or more precisely, individuality-in-community- is clearly present at a deep-structural level in the spatial nomenclature of the biosphere reserves, for example, in the term that brings us together for this symposium, "wilderness." As a synonym for "core area" Batisse (1986) uses "wilderness." Environmental philosopher Holmes Rolston III (1986), writing of a trip to Lake Solitude in the Rocky Mountain National Park, describes the passage into wilderness as leaving the company of persons and entering into a kind of dialogue with the natural order. Nor is it difficult to imagine that beneath the buffer and transition zones there are comparable images, such as that of the garden, symbolizing "mixed communities" of humans, animals and plants.

The language of community has had a long association with the ecological perspective in the natural sciences. It was out of the science of ecology, originally defined as "the science of communities" (Worster 1979; Engel 1983), that the MAB program emerged, and in recent years the science of human ecology has increasingly informed it. The Australian biologist, Charles Birch, decribes the relationship this way:

> <u>For the ecological model the community is that group of people and other creatures who most deeply affect one another, whose lives are most richly intertwined</u> . . . [The ecological model] asserts that the well-being of others contributes to the well-being of oneself . . . Families who attain wealth at the expense of the impoverishment of their communities do not thereby attain true well-being. A village which supplies its current needs by deforesting all accessible hills is not well-off as it passes prospects of misery on to its children. We are members one of another and our individual happiness is bound up with the happiness of others. The economic goal is the enhancement of the sustained well-being of communities by the most appropriate use of those things which the community needs. This entails that the community attain its own well-being in ways that allow and enable other communities to attain theirs (Birch and Cobb 1981, emphasis added).

The Biosphere Reserve Concept and the Issues of Global Conservation and Development

The specific constellation of symbols and moral norms by and through which we interpret the meaning of the biosphere reserve concept must not only fittingly express a basic co-evolutionary vision, it must also empower persons to respond contructively to the conflicting values and forces that make up the complex environmental struggles of our age. One reason so many of us are enthusiastic about the biosphere reserve concept is that it gives us a general if vague sense of direction in the midst of these conflicts. But it must also give us moral guidance in the midst of the daily choices we face. It must be clear regarding the constituencies we are to serve and the specific social and ecological values we are to promote. The ultimate success of the biosphere reserve concept depends upon its success in doing these things.

There are two closely related global issues in particular that the international environmental movement is currently facing and which the symbolism and ethics of the biosphere reserve concept must be able to speak about with clarity if it is to be effective in the years ahead.

The first issue is how we are to understand and evaluate the basic processes of globalization which are occurring throughout the planet. The term "globalization" is frequently used to refer to the fact that we are participants in processes by which the world is increasingly a single place--both with respect to a recognition of a high degree of interdependence between spheres and locales of social activity across the entire globe, and to the growth of consciousness pertaining to the globe as such. However, what is taking place globally is not one thing, nor necessarily good. The world may become unified on terms that are beneficial or detrimental to the welfare of its inhabitants. And, in fact, there are conflicting social, economic and political processes taking place, with conflicting social and environmental consequences.

Most observers see two opposing processes taking place. The most domiant of these is the global process of societalization, the shift from Gemeinschaft to Gesellschaft, from traditional communities to societies of autonomous individuals, with human interaction at all social levels increasingly based upon principles of instrumental rationality undergirded by Western science and technology (Wilson 1982). Dasmann (1984) describes this global process as a transition from a world composed of "ecosystem" people who live within the constraints of of their local region, to "biosphere" people who draw on the resources of all ecosystems without regard for their long range human or environmental welfare. Two major forces behind this overall trend are the expansion of the world exchange economy with its attendant growth in mass consumption, economic stratification, social dislocation, and biological and cultural homogenization (Wallerstein 1974, Norgaard 1986); and the emergence of a world system of sovereign military and industrial nation states, dominated by coalitions of wealthy and heavily armed nations with the capacity to dominate weaker nations (Kim 1984).

Opposing this dominant process are several interlocking counter-movements. One is an emergent world polity, entailing a sense of collective selfhood and solidarity across the human species, and an effort by increasing numbers of cultural elites to elaborate what Meyer (1980) calls new types of "justification for world-level rules," including new world views that infuse the natural world with "meanings that impose or require limitations on human society." The emerging ecological world-view is an example of the latter. According to several observers, one of the defining characteristics of the emerging global polity is federalism--the world organized as a federation of de-centralized self-governing local polities. The tenuous movement toward the reclamation of what Esteva (1987) calls "peoples' space" is an example. A second counter-movement is the emergence of overtly religious and ethical movements with global constituencies and purposes, many of which seek to de-legitimatize the global exchange economy and build more communally responsible patterns of human association (Kothari 1981).

In the midst of these two opposing kinds of global processes, ordinary human beings are struggling at deep symbolic levels to understand anew their relationships to one another and to the planet. Studies of the leading "geo-metaphors" of modern culture suggest very divergent perceptions of what these relationships are and ought to be (Noel 1986).

The two most far-reaching symbolizations parallel the two sorts of processes taking place. Both emerged into collective consciousness at the time of the space programs of the late 1960s, the time in which MAB was born. On the one hand, there is the cluster of metaphors--mechanism, patriarchy--associated with the notion that humanity's evolutionary destiny is to technologically master (and in some sense "transcend") the physical conditions of this planet. On the other hand, there is the cluster of metaphorsorganicism, femininism--associated with the notion that humanity's evolutionary destiny is to identify more profoundly with the Earth, its true home (Merchant 1980). Both of these are rooted in modern consciousness, but they were never so sharply juxtaposed as in the contrast between the American space project's symbol of Apollo, the ultimate expression of human technological mastery, and the symbol of Gaia, which spontaneously swept public awareness after the first picture of the Earth from space.

One of the appeals of the biosphere reserve idea is that it recognizes the fact that globalization is occurring. Moreover, most interpreters of the concept place a generally positive valuation on it. In my view, they do so because they are working out of a basic perspective that is co-evolutionary. They envisage globalization in terms of their hopes for a new world polity which will support a deeper integration of human civilization with itself and with the rest of nature, a polity which will preserve and enhance the rich biological and cultural diversity of the planet. Only the symbolism of community explicitly confirms that basic perspective and hope, however. The uncritical and exclusive use of the language of resource management does the opposite: it symbolically and morally aligns the biosphere reserves with the expansionary tendencies of the global exchange economy and the technologically advanced military-industrial nation-states.

The other global issue that the international conservation movement faces is closely related to the first and has to do with the meaning of "sustainable development." It is now generally recognized by development ethicists that any development paradigm presupposes some normative concept of progress, some development goal, or telos, and therefore is moral in character. But what kind of development is morally legitimate on social as well as environmental grounds?

Whereas many still defend development patterns that enhance the global exchange economy and the nation-state on the grounds that they are essential to human and even environmental well-being, others denounce the dominant forms of development as closer, in actual practice, to "misdevelopment," or "anti-development" (Dumont and Mottin 1981). Indigenous peoples--the poor, women, people of dark skin--these are in the forefront of those challenging the moral legitimacy of development as it has been practiced by the major economic and political powers. The new development paradigm gaining legitimacy among these constituencies stresses "alternative" values, such as the primacy of basic needs satisfaction, the elimination of poverty, environmental health, the importance of human rights, political self-determination and democracy (Goulet 1971). The World Commission on Environment and Development moves close to making these alternative values the substance of its definition of "sustainable development" as well (World Commission on Environment and Development, 1987).

This is an issue that intimately affects the policies of the biosphere reserves and can only grow in importance in the years ahead as the scientific information and genetic resources of the reserves become more valuable. An excellent example of the problem is found in the use currently being made of the discovery of a new species of perennial corn, *Zea diploperennis,* in the Sierra de Manantlan Bisophere Reserve of Mexico. The germplasm of this species, and the scientific information gained about it, are currently being used by the corn producers and universities of developed countries for commercial and research development purposes. The discovery is not benefitting the communities of the biosphere reserve. Is this morally legitimate "sustainable development"? Or is this an example of "economic and socio-political models (international as well as national) that encourage natural resource destruction and generate social inequalities and poverty" (Eduardo Santana, Rafael Guzman and Enrique Jardel, 1988)?

The future of the biosphere reserves is dependent upon the resolution of this kind of moral issue. They will be very different places if the processes of First World technological development continue to grow than they will be if the movement toward a new global polity and an alternative development paradigm gain momentum. But what guidance does the biosphere reserve concept itself offer for this issue? Which processes should be morally encouraged and which rejected? What constituencies do the reserves ultimately serve? Does not the biosphere reserve idea, by its very definition, entail a social as well as an environmental ideal? If so, does this not have implications for the kind of political and scientific coalitions and strategies that the advocates of biosphere reserves pursue?

It is evident that when we use the language of resource management, we tilt public thought and action in the direction of the accepted processes of global development--the very processes, by many analyses, currently responsible for the destruction of biological and cultural integrity and diversity (Norgaard 1986). We inadvertently ally ourselves with those global agencies seeking to "manage" people and nature rather than "liberate" them for political freedom and mutuality.

The language of community, in contrast, tilts public discussion in the direction of processes supporting an emergent global polity, citizen-based movements seeking more humane and democratic forms of association, and the maintenance of biological diversity.

It is clear to me that the biosphere reserve concept is affirmative of global processes seeking to establish a more just global polity and an alternative development paradigm. Among the characteristics of the concept that lead me to this view are its basic ecological premise, its concern for the long-term well-being of local communities and ecosystems, and its emphasis upon cooperation rather than competition at all levels of activity. But the concept is so laden with resource conservation terminology and its assumption that the solutions to our problems are primarily technical, that this is by no means clear to the public. The symbolism and moral principles of a universal and just global community are not yet part of the concept's explicit definition.

Conclusion

I believe the moral clarity and practical effectiveness of the biosphere reserve concept would be substantially increased if it were clearly stated that the symbolic and moral language of community, rather than the language of resource conservation, is the primary framework for interpretation. This would mean that biosphere reserves are, first, centers for the preservation and renewal of human and natural community, and second, a management category; that each reserve is a commons before it is a resource; that the symbol of the Earth as a mosaic of co-evolving communities is the ultimate context of scientific research and social action alike; and that the primary ethical imperative is not to master or manage nature, but to participate in a nurturing and respectful way in its unfolding splendor and richness--in the words of Michel Batisse (1982), to realize a lasting "partnership between Man and Nature."

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ON WILDERNESS, NATIONAL PARKS, AND BIOSPHERE RESERVES

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ABSTRACT. Biosphere reserves are distinguished from other managed areas by the coordinated pursuit of conservation, logistic, and development roles within the framework of a global information-sharing network. By encouraging scientific, educational, and demonstration activities within a particular bioregion, biosphere reserves represent "landscapes for learning"--for developing the knowledge, skills, and attitudes required for rational, culturally appropriate human uses which maintain ecosystem processes and biological diversity while fostering social cohesiveness and pride in indigenous traditions. Wilderness, national parks, and biosphere reserves are discussed as complementary, mutually reinforcing concepts. The potential of biosphere reserves to emerge as a symbolic focus for global efforts to demonstrate harmony between Man and Nature is discussed.

KEY WORDS: Biological diversity, biosphere reserves, conservation, protected areas, symbolism, wilderness.

In acidic deposition, the greenhouse effect, pollution of the seas, and the unprecedented destruction of wildlands, we are witnessing the biospheric consequences of myriad decisions on the use of the planet's ecosystems. Such influences are now converging as a juggernaut upon the legacy of biological evolution, and all the options for the future the legacy embodies.

A century ago, the penalties for violating natural laws were paid locally. Today, technology gives us biospheric dominion. Governments, international agencies and corporations routinely make decisions affecting large areas and the global commons. The planet's surface estate soon will be fully allocated to meet human needs. Our future quality of life, if not our survival, will depend on how we manage the remaining stage of the allocation process. To address the challenge, we must demonstrate the benefits of conservation in every corner of the world. We will need to demonstrate the interdependency between the material, social, cultural, and spiritual dimensions of human existence and the maintenance of the planet's biological diversity. And we will need to become proactive in cooperation on many levels, and in sharing the results of our efforts.

Urgency and uncertainty have prompted global discussion on how protected areas can aid humanity in its quest for maturity. It seems clear that our collective emergence from adolescence must embody the harmonious integration of conservation and economic development, and that protected areas must now play a key role in this process. We must develop this role under the diverse ecological, socioeconomic, cultural and institutional conditions of different parts of the world. In this paper, I shall review the case for biosphere reserves as standard-bearers of these efforts.

Today, wilderness and national parks are twin pillars of global conservation. Each embodies positive and powerful concepts which motivate legions of devoted followers around the world. Each, for different reasons, has become part of the civil religion of many nations. Wilderness is an intensely spiritual concept, symbolizing the organic unity and goodness of Creation. It embodies an intrinsic morality, which motivates human behavior based on respect for Nature and natural laws. It provides an ultimate context for spiritual inspiration and renewal. Untrammeled Nature, at once awesome and foreboding, beautiful and mysterious, has inspired great religious figures, philosophers, and leaders in the arts and sciences for millenia, as it has provided a challenge for explorers and a context for the lives of indigenous people throughout human evolution. In an increasingly urbanized world, it is a tribute to our humanity that people recognize the significance of wilderness, in its various interpretations, to the progress of human civilization and passionately seek to protect Earth's diminishing wild land heritage. The legal preservation of wilderness areas in many countries is high testimony to Man's respect for Nature, and the intrinsic value of the wilderness legacy.

The national park concept is generally acknowledged to have originated with the establishment of Yellowstone National Park in 1872. The idea of legally protecting natural treasures for the enjoyment of future generations took hold rapidly during a century of unprecedented nation-building, a process which now appears to be largely complete. Throughout the world, national parks have come to symbolize national identity and pride, and protectiveness toward unique features of a nation's heritage. They are prime showcases for tourism, important centers for outdoor recreation and conservation education, and mainstays in the economies of scores of nations. They are also, in a sense, the ambassadors of goodwill in the protected area community (Raithel, pers. comm.), providing special opportunities for fellowship among families and friends, as well as among people of all religious, racial, cultural, and economic backgrounds. No other internationally recognized category of protected area provides such a symbolic rallying point for the conservation movement's global constituency as does the national park.

The biosphere reserve concept is barely a decade old. Resources for its implementation have been limited. There is thus still little public recognition or constituency. Nevertheless, the symbolism is compelling and uniquely in tune with contemporary needs and directions in global conservation (Engel 1985). As a reserved "landscape for learning" in a particular region of the biosphere, each biosphere reserve symbolizes humanity's efforts to develop the knowledge, skills and attitudes needed to solve interrelated environmental, land use, and socioeconomic problems. It represents a collective center for marshalling knowledge and perspective--from natural and social scientists, the managers of many types of administrative areas, and resource users, including indigenous people. The concept resonates with efforts to strengthen local, regional, and global cooperation in conserving biological diversity, while providing for sustainable, culturally appropriate use of the world's ecosystems. The unique global network, and each site within it, thus symbolizes a global unity of purpose in achieving this goal. The biosphere reserve is more than just a international designation. Like the national park before it, it is an idea whose time has come--a concept capable of expanding the constituencies for conservation.

Establishing the public image of biosphere reserves has been challenging. Because each unit must have a protected core area, national parks and wilderness areas have been the initial building blocks of the network. By the program's sixth year (1982), 84% of the biosphere reserves were superimposed hectare-for-hectare on national parks and other strictly protected areas (Miller 1983). Although such areas well fulfill the conservation role and sometimes the logistic role, they cannot directly do much to further the development role (for a discussion the multiple roles of biosphere reserves, see Batisse [1986]). The association of biosphere reserves with national parks has posed some continuing problems. In the United States, park managers have tended to see the designation as a gratuitous honor, rather than an opportunity to obtain perspective for solving management problems and to strengthen bioregional cooperation. Managers of multiple use areas, on the other hand, have worried about loss of management prerogatives because of the perceived dominance of strict conservation areas. These problems will diminish as operational models of biosphere reserve concepts develop in the field--a process which has accelerated in many areas during the last year, as evidenced in the case studies described in this symposium.

Today, national parks in many countries increasingly reflect the objectives of biosphere reserves--more cooperation among adjacent land managers, more local involvement, more emphasis on the role of research and public education. Where the national park idea has only recently gained acceptance, countries have sometimes been reluctant to entertain the new concept. However, in countries lacking strong systems of resource protection, large biosphere reserves are now being established with considerable success under laws which clearly specify their multiple roles. Mexico, in particular, has successfully demonstrated the practical benefits of biosphere reserves as a legal category of protected area. This approach would be impossible in countries like the United States, which have legal land management systems with strong public constituencies. In such situations, voluntary cooperation involving the conservation, science, and economic development sectors forms the basis for biosphere reserve programs.

Under UNESCO guidelines, an area or group of areas must have the potential to carry out the conservation, logistic, and development roles to be designated as a biosphere reserve (UNESCO 1987). Nominations now must include extensive information relative to these roles, as well as a map showing the configuration of core, buffer, and transition areas. Managers must sign a general statement of commitment to the Action Plan for Biosphere Reserves--a requirement that, in time, may help achieve a greater uniformity of purpose than for other categories of protected areas (UNESCO 1987). UNESCO now encourages the naming of biosphere reserves to reflect their region's natural or cultural identity. Sixteen of the 24 units designated since 1985 reflect this approach, and thus provide a symbolic focus for bioregional cooperation (see Table 1). Most are large, diverse landscapes which provide good prospects for carrying out the multiple roles of biosphere reserves. In the United States, we are gradually incorporating existing national park biosphere reserves into larger bioregional associations which can better fulfill these roles.

Wilderness areas, national parks, and biosphere reserves are complementary and mutually reinforcing. All are, ideally, large areas having strong conservation objectives, which differ according to the human needs they principally serve. In wilderness, the focus within the area is on <u>spiritual needs</u>. Thus, wilderness management emphasizes maintaining the natural aesthetic context for personal relationships between Man and Nature, and for types of recreation which foster such relationships.

Table 1. Summary of Biosphere Reserve Designations, 1985-1987.

Country	Name	Size in ha.	Year	Misc.
Algeria	Tassili National Park	7,200,000	1986	Mult. uses
Argentina	Reserva Ecol. de Nacunan	11,900	1986	
Bolivia	Beni Biological Station	135,000	1986	Massive expansion as Beni Biosphere Reserve planned
Benin	Pendjari BR	880,000	1986	
Burkina Faso	Foret Classe de la Mare aux Hippopotomes	16,300	1986	
Canada	Long Point BR	27,000	1986	
	Riding Mountain BR	297,591	1986	
China	Fanjingshan Mtn. BR	41,533	1986	
	Xilin Gol Natural Steppe Protected Area	1,078,600	1987	
	Fujian Wuyishan Nat. Res.	56,527	1987	
Cuba	Cuchillas del Toa BR	41,533	1987	
	Peninsula de Guanahaca-bibes BR	101,500	1987	
	Bacanao BR	84,600	1987	
Czechoslov.	Palava Prot. Landscape Area	8,017	1986	
Mexico	El Cielo BR	144,530	1986	
	Si'an Ca'an BR	528,147	1986	
Netherlands	Waddensee BR	260,000	1986	(Nomination of companion area in Germany pending)
Spain	Sierra Nevada BR	190,000	1986	
Sweden	Lake Torne Area BR	96,500	1986	
Ukrain. SSR	Ashaniya-Nova Zapovednik	33,307	1985	
U.S.S.R.	Lake Baikal Region BR	559,100	1986	
	Tzentralnosibirskii BR	5,000,000	1986	
U.S.A.	Carolinian-So. Atlantic BR	125,545	1986	
	Glacier Bay-Admiralty Island BR	1,515,015	1986	

National parks serve spiritual needs, but most also contain infrastructure to enable enjoyment of Nature by large numbers of visitors with diverse interests and backgrounds. Management emphasizes maintaining a natural environment and a social environment conducive to this enjoyment, and in fostering a conservation ethic through public education in a social context. Indeed, in many countries, meeting the social needs of an increasingly affluent and urban population is the major business of park management. Because of the importance of providing memorable experiences, maintaining resources symbolizing national identity, populations of charismatic animals, and other special or unique features takes on particular importance.

In biosphere reserves, a dynamic landscape of natural and managed ecosystems provides the context for meeting human needs for information. The landscapes are intrinsically information-rich--a macroscale expression of the informational legacy of biological evolution and the coevolution of ecosystems and human societies--a legacy awaiting to be discovered and applied through the media of science, appropriate technology, and human volition. Because people live in the buffer and transition areas of biosphere reserves, they are immediate beneficiaries of the information flow. As bioregional hubs for generating and sharing information, biosphere reserves help societies to manage ecosystems to maintain a range of spiritual, social, and material benefits. Biosphere reserves deserve the support of conservation, research and development sectors, as all depend on the kinds of information biosphere reserves provide. Because they uniquely symbolize the role of sharing information in human progress, biosphere reserves are a fundamentally new dimension in global conservation.

In the United States, we are building many nested associations involving legislative wilderness within a national park, and a national park within a larger biosphere reserve, which grows in size as it develops in function. For both symbolic and practical reasons, such a union affords especially good opportunities for conserving the ecological processes and biological diversity upon which the benefits of each category depend.

When a wilderness area or national park becomes part of a biosphere reserve, it is recognized as a global benchmark of ecological health. Over the years, an increase in nondestrucive scientific and educational uses should provide direct benefits in terms of better information and skills for protection and management. Use of MAB as a neutral aegis for cooperation with local people can enhance local political support for protection. As a control for manipulative research elsewhere in the biosphere reserve, a park or wilderness area can provide perspective for managing economic uses while conserving biological diversity. Through the network, information is shared on the effects of pollutants, land conversions, climatic changes, and similar influences affecting many regions. These are the very influences which managers cannot mitigate directly- -where contributing information to the decisionmaking process is often the best way to protect the public interest in these areas. Inclusion in a biosphere reserve reinforces the trend toward integrative approaches in management (Eidsvik 1985, Gilbert 1987), especially when multiple administrative units are included (Gregg 1983, Gregg in press). In sum, by expanding the benefits of national parks and wilderness areas to society, biosphere reserves can help build new constituencies for their protection (Barbee and Varley 1985).

In developing countries, achieving conservation goals usually requires attention to the welfare of local people through culturally appropriate development, conservation education, and local participation (Lusigi 1984, Halffter 1980, 1984). In such situations, biosphere reserves may be the most attractive option for conserving large areas containing human populations. It is conceivable that a national park or wilderness area could someday be established within the framework of such biosphere reserves. However, these would involve the active support and involvement of local people, in contrast with the forced displacements associated with many existing protected areas.

Biosphere reserves should be part of every nation's conservation and economic development strategy, a reflection of its commitment to international cooperation, and evidence of its contribution to sustainable use of the world's ecosystems. The international agencies and organizations participating in MAB should develop the means for completing the five-year program of the Action Plan for Biosphere Reserves on schedule--by 1989. (The recent report, "World Resources 1986" [World Resources Institute and the International Institute for Environment and Development 1986] states that "if all these actions are carried out, biosphere reserves might become the most important component of the world's protected-area system.") We need to improve the scientific basis for selecting and expanding biosphere reserves, the availability of information on existing biosphere reserves, and practical guidance for management. Financial and professional support must be provided for biosphere reserve programs in areas selected to demonstrate the flexibility of the concept. Finally, UNESCO, and its partners in MAB, should begin planning for a second Biosphere Reserve Congress, to refine the Action Plan and chart the agenda for the 1990s.

Biosphere reserves need champions among domestic nongovernmental organizations to develop political support for implementing the concept. Internationally, champions are needed among organizations to provide technical support, especially in developing countries and among indigenous people. International development agencies need to give priority to biosphere reserves for pilot projects to enhance traditional agroecosystems, restore the productivity of degraded landscapes, and demonstrate the value of conservation in rural development. The media need to become involved. Universities need to incorporate biosphere reserves in their curricula, promote research and training in biosphere reserves, and help develop the philosophical, scientific, cultural, social, economic, and operational dimensions of a new concept for influencing man's relationship with the environment.

Will the intense volition which marks wilderness and national park concepts also develop around biosphere reserves? A 70-nation network is established. A global Action Plan has been widely endorsed. There is now a considerable literature on biosphere reserves. National and regional symposia and workshops are now a fact of life. New programs involving biosphere reserves, such as the Smithsonian/MAB Biological Diversity Program, are providing momentum. Individual areas are taking action to define their role as biosphere reserves. There is more public visibility than ever before. A small, but growing cadre of dedicated proponents is established. However, only time will tell whether biosphere reserves will become new "sacred spaces" in the 21st century (Engel 1985), and rallying points for our collective efforts to build harmony between Man and Nature.

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BIOSPHERE RESERVES AND THE WORLD CONSERVATION STRATEGY II

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ABSTRACT. Both the Biosphere Reserve Program and the World Conservation Strategy provide the context within which all protected areas should be planned and managed. The example of La Tigra National Park in Honduras is used to demonstrate that parks as "islands" will not survive and that regionally-designed landscapes blending both conservation and development are the only solution. The time has come for more application of these tools and policies at the field level.

KEY WORDS: Biosphere reserve, national park, World Conservation Strategy, Honduras, watershed protection.

The question of questions for mankind . . . is the ascertainment of the place which man occupies in Nature . . . What are the limits of our power over Nature, and of Nature's power over us?

– T. H. Huxley (1862)

An Illustration

A scant ten miles from Tegucigalpa, Honduras' crowded capital, lies one of the wonders of nature--La Tigra National Park. A century ago, the entire Central American isthmus was carpeted in green, like La Tigra. Now only a few beleaguered relicts remain. La Tigra is one such--an enchanting world of green, floating as if in suspension over the eroded valleys and scarred hillsides surrounding the capital of one of Latin America's poorest countries. Enter the forest and you become submerged in a world of green--a world dripping with ferns and epiphytes, where streams flow through the dense underbrush and an orchestra of tree frogs and insects is perpetually tuning up. This forest provides a home for the puma, the collared peccary, and it is one of the few remaining fortresses of the quetzal--a resplendent, emerald-colored bird revered by the Amerindians as a messenger from the Gods.

But back at Tegucigalpa, Honduras' capital, we see a drearily familiar development case study. Only twenty-five years ago it was a sleepy city of under two hundred thousand people. Today, the trickle of migrants in from the rural areas has swelled into a flood that washes onto the barren hillsides as slums as grim as those found elsewhere in Latin America. The peasants are drawn to the capital because their land has been devastated by poor management, because the country's land tenure situation does not permit them a real opportunity to make a livelihood for themselves and their families, or because they are drawn by the promise of jobs and bright lights in the city. There are not nearly enough jobs in the city and once the link with the land has been severed, it is very hard to reestablish. Instead they wait, grow restless and place added pressure on

Government services to deliver a minimum of support so that they can live out their lives in dignity.

And how are the Government services coping? With great difficulty; all the indicators suggest that the battle, far from being won, is slowly being lost.

Take, for example, the issue of water supply. Currently, less than 80% of the population has regular access to clean water. With the population of the capital growing at 8% per year, this gap is widening. Each year in the dry season there is serious water rationing in all parts of the capital and the rationing covers longer and longer periods and affects more and more people.

The water comes from two principal sources---the Guacerique valley, where water is captured at Los Laureles dam, and La Tigra National Park, where the water is captured directly from surface run-off. The Guacerique watershed is badly degraded and landless peasants are colonizing it at a rapid rate. As they move up the remaining forested slopes, the capacity of the watershed to deliver regular water supplies is diminishing at an accelerating rate. Los Laureles dam is already experiencing a serious siltation problem and a plan to build a second dam of greater capacity has recently been shelved because the watershed is so degraded that nobody will guarantee the necessary investment.

La Tigra, which supplies an average of 55% of Tegucigalpa's water, is also threatened. Despite the fact that it is a national park, it is not safe from exploitation and non-sustainable use. Indeed it is paradoxically in many ways <u>because</u> it is a national park that it is so threatened. As a national park, it has the lowest priority in terms of national concerns. It is managed by a division of a department that is right at bottom of the totem pole of Government priorities when it comes to political power and influence.

La Tigra supplies water at less than 5% of the cost of the water from Los Laureles. It can do so because no dam is required; the high elevation of the cloud forest obviates the need for pumping stations and the "natural filter" of the forest ensures that it requires no treatment. The mere differential between this water and the water from Los Laureles has a value of US $17,000,000 per year and this is using narrow, conservative calculations.

La Tigra is thus an essential resource for the country; indeed, it can be regarded as a strategic resource. In recent years there has been serious rioting in the slums during the peak of the dry season. The water situation is destabilizing the current Government and undermining its efforts at democratization. If the situation persists, it does not take much imagination to see the long-term consequences, or at least the long-term risks. The slums of Tegucigalpa have often been described as being filled with "ecological refugees," and the ecological refugee of today can be the urban guerilla of tomorrow.

What, then, has prevented La Tigra from effectively contributing to the conservation and development of Honduras? Currently, the amount of money being devoted to management of La Tigra forest is about US $100,000 a year, of which a substantial part comes from the World Wildlife Fund (WWF) and other outside donors. With this level of investment La Tigra will be eaten away over the next decade or so, and essentially lost to the economy, not to mention to the environment.

Assuming that we all agree it is essential to save La Tigra (as a source of water, as well as quetzal habitat), how do we go about it? The only way to do so is to stabilize the use of resources on the part of the human communities living around La Tigra, and to offer them a way of improving their standard of living without using the park's resources unsustainably. In other words, action aimed at protecting the park must in fact take place outside it.

Lessons from La Tigra

Sadly, La Tigra National Park is not alone in its predicament. It is in fact typical of management policies and procedures extant in many protected areas worldwide. Miller (1982) has summarized these as follows:

1. Island Mentality. The management of national parks and other types of protected areas has focused upon matters internal to the boundaries of individual reserves. This "island mentality" has led to a general lack of interaction with surrounding lands, peoples and institutions.

2. Narrowly-viewed Benefits. The benefits provided by protected area management have been viewed narrowly and have shown little relation to the basic needs of people. Management activities and public information have generally dealt with relatively few benefits, such as recreation and wilderness preservation in the case of parks, or timber in the case of forest; only passing reference has been made to the vast role of protected areas in watershed maintenance for downstream food production, and for research on agricultural, pharmaceutical and medical properties of wild flora and fauna. In other words, reserves have been sold short.

3. Out-of-date Management. Management has often been conceived and implemented based upon conventional wisdom and dogma not reflecting the expanding knowledge base available from science and technology. Examples include the role of fire, the handling of locally overabundant large mammals, laissez-faire attitudes toward recreation in protected areas, and tight restrictions on research and the collection of genetic materials.

4. Inadequate Public Information. Information provided to the public on the role and values of wildland and natural resources have been restricted to popular, often sentimental items with little reference to vital linkages between people and their natural resources. Thus, while the public has been able to gain an appreciation of "the birds and the bees," they have missed the connection between the work of protected areas and their water faucet, dinner table, fireplace, doctor's office, home, school and place of worship.

5. Weak Scientific Foundation. The long-term biological viability of many parks and reserves is in serious doubt. Most existing protected areas were established before the emergence of the science of conservation biology and other ecological benefits from scientific support. Most parks are biologically too small, have irregular shapes and jagged edges, and have population sizes which may be too small to ensure the genetic viability of key species. The basic integrity of ecosystems, including important ecological processes, and the habitat requirements of species often require territory outside the areas under protection.

Both the World Conservation Strategy and the biosphere reserve approach, advocated under UNESCO's MAB program, provide a context for addressing these issues. Both reinforce each other in attempting to reconcile conservation and development, bringing benefits both to the park and the surrounding rural population. Both are based on the premise that conservation and development must go forward together, and that neither can succeed without the other. Both are attempting to design an answer to Huxley's question of the place which Man occupies in Nature.

Towards the World Conservation Strategy II

The World Conservation Strategy (WCS) was published in 1980 by IUCN, UNEP and WWF, with the collaboration of FAO and UNESCO. It quickly became a guiding document for the international conservation movement, providing the basis of the programs of IUCN, UNEP and WWF. It has been endorsed by the United Nations General Assembly and the UNEP Governing Council and by most of IUCN's membership. It has been translated into 16 languages. The WCS is a major landmark towards international cooperation for the conservation of renewable natural resources for sustainable development.

In the seven years since the WCS was published, considerable progress has been made in some areas. National Conservation Strategies have been prepared, or are being prepared, in some 30 countries, often with support from bilateral assistance agencies as well as UNEP, WWF and IUCN; the message of renewable natural resource conservation for sustainable development has been spread particularly by the WCS partners; problems of wildlife, genetic resources and tropical forest conservation and the global commons have been addressed through UNEP's Program; the cooperation between IUCN and SCAR on Antarctica; FAO's work on soils policy and tree and crop genetic resources; UNESCO's efforts in the Man and the Biosphere Program; major international conservation agreements such as the World Charter for Nature, the CITES and the Migratory Species, the World Heritage and the Wetlands Conventions help focus international attention on key sites and species; the WRI-IIED report on World Resources; the Tropical Forestry Action Plan now being supported by the World Bank, UNDP, WRI, IUCN and the bilateral and multilateral community; and finally, the World Commission on Environment and Development Report.

However, the WCS has several gaps, notably in the relationship between population and development, technology, industry, agriculture, health, human settlements, environmental economics, security and the environment, traditional resource management systems, and environmental ethics as well as the role of special segments of the population such as indigenous people, women and youth. Further, the WCS needs review as scientific knowledge and understanding of changes in both the conservation and development related value systems evolve. Consequently, the WCS should not be considered as a "finalized" product, but rather one that comes under continuous review. To help address some of the shortcomings of the WCS and to conduct the first international systematic review of its contents, the World Conservation Strategy Conference met in Ottawa, Canada in June 1986, attended by 500 delegates from some 80 countries.

The Conference recommendations called for the preparation of new sections to be included in a second edition of the WCS and urged a clearer definition of the relevance to sustainable development of specific interests (e.g., indigenous people) and issues (e.g., peace and security). Relevant recommendations explicity called for sections to relate sustainable development to (1) advances in economic theory and practice; (2) ethics, culture and tradition; (3) international cooperation, peace and security; (4) population; (5) sector-based strategies such as agriculture, health, human settlements and industry; (6) education; (7) indigenous people; (8) women; and (9) criteria for appropriate technology.

The major conclusion drawn from the conference is that a new edition of the WCS should be prepared. IUCN has now embarked on this exercise. In the second edition the basic concepts and principles of the original WCS will essentially remain the same, but gaps will be filled, themes not covered or insufficiently treated will be included or expanded on, and up-to-date information will be included based on current knowledge and that gained from experience in working with the first edition of the WCS. The experience of national, regional, sector-based and biome-based strategies for conservation and sustainable development will also be incorporated. The new edition will be more action-oriented than the first version and will be written in an easily readable language suitable for policy-makers and the educated public, while ensuring scientific accuracy.

Biosphere Reserves and WCS II

The tone of the revised WCS will focus much more on implementation. As Mostafa Tolba noted in his remarks to the June session of the UNEP Governing Council: "The time of the doomsayers is over. The means exist, only the will is required. We need less talk, less theory and more action." The challenge now is to apply the tools and policies and strengthen our will to put the WCS principles to work.

The Biosphere Reserve program is in the position to become a major player in implementing a portion of WCS II. Since the WCS first appeared in 1980, the MAB program has considerably matured and now provides the intellectual framework for application. The network of biosphere reserves has grown to 252 sites in 1986 from 161 in 1980. The Action Plan prepared subsequently to the First International Biosphere Reserve Congress in Minsk has now been endorsed by the participating partners and outlines the steps that need to be taken.

The program, however, needs to move forward on several fronts before it can more effectively supplement the WCS. For instance, there is still much to do to develop a representative system of biosphere reserves. Currently there are many gaps and many of the existing parts do not fit together. Secondly, there is a wide disparity in what biosphere reserves mean from country to country. In the USSR, for instance, the emphasis is on research and monitoring in strict nature reserves, while in Mexico the focus is on sustainable use. Further, there has been much useful research in the biological sciences but virtually none on the socio-cultural aspects which are needed to address Huxley's "question of questions." And finally, vastly increased resources for implementation of the action plan at the field level need to be identified.

Clearly, "showtime" has come to put biosphere reserves to the test on the ground as a model of man's partnership with nature.

Applying the Lessons

Back at La Tigra, the biosphere reserve philosophy is, in fact, being applied as a joint exercise of the Government of Honduras and IUCN with funding from Norway. A detailed assessment of the value of the park in supplying water has been presented to a wide range of government institutions, from the President through to the parks office. A major perceptual change on the empirical values of the park has been effected. Second, a plan of action for the buffer zone surrounding the park has been prepared; it involved consultations with eight different government institutions and the affected rural communities. A detailed socioeconomic and attitude study of the surrounding residents has been undertaken in order to determine what types of actions could be realistically designed and would gain the support of those communities, and what kinds of incentives would be needed to strengthen this.

Through numerous workshops and by widening the traditional view of the park to a regional planning perspective, a new view of La Tigra's future has emerged. This is described in an action proposal that outlines the range of activities that need to be undertaken, what organizations will participate, and how the local residents will be involved and benefit. Endorsement at the highest political levels has been received and support for implementation (US $ 3.5 million) is now being sought.

La Tigra as an "island" will not survive. As an element in a harmoniously designed regional landscape, it might. In any case, it points the way and reflects the direction that the biosphere reserve approach and the WCS II in tandem will increasingly lead us.

One final point should be mentioned. La Tigra was chosen as a case study because, like most of the world's protected areas, it is not a biosphere reserve. However, like all protected areas, it should be managed in its wider context, taking into account its broader role in sustaining Honduras and its people.

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ROLE OF BIOSPHERE RESERVES IN ECOSYSTEM RESEARCH

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Ecosystems are extremely complex, involving interactions among environment, biota, and disturbances. Ecological phenomena are also characteristically long-term processes of various types. Examples include episodic events (e.g., many disturbances), slow processes (e.g., succession), and subtle changes in parameters in which it is difficult to identify trends due to high levels of variability (e.g., acid precipitation). The complexity and long-term perspective in ecosystem research strongly influences approaches and, consequently, the potential contribution of biosphere reserves to the science.

Elements needed for ecosystem research include: (1) dedicated research areas which have the stability necessary for long-term observations and experiments; (2) sites with manipulative potential so that management-oriented experiments are possible; (3) scientific cadres which are interdisciplinary and experienced in collaborative research; (4) an infrastructure which can provide the necessary continuity and logistical support; and (5) long-term data bases for key biological and physical parameters. Several of these requirements (3 to 5) are best met with sites that already have major, current research programs.

Major needs in ecosystem science include: (1) synthesis of existing information, including the development of predictive models, such as successional models of the FORET type; (2) comparative studies which allow extrapolation of information along major spatial and temporal gradients; and (3) analyses of phenomena at larger spatial scales, specifically including processes operative at the scale of landscapes. Many of these needs are directed at the generic problem of putting research in context for predictive/ extrapolative purposes; much current and past ecosystem research is strongly deficient in providing essential temporal and spatial perspectives.

The current history of ecological research in biosphere reserves is very mixed. Many Forest Service biosphere reserves have a long history of long-term experiments and observations, including watershed and forest plot studies. These studies have been deemphasized and many abandoned since 1960, however. Research in National Park Service biosphere reserves has been sporadic. There are some outstanding programs, such as at Channel Islands and Everglades. Projects carried out through the National Acid Precipitation Program have provided a major impetus at several locations, including Sequoia-Kings Canyon National Parks. Other national parks have weak or declining programs in ecosystem research. The major supporter of ecosystem research in biosphere reserves is the National Science Foundation, through both its Ecosystems Studies and Long-Term Ecological Research (LTER) Programs. Fifteen sites have been funded as LTERs and receive 5-year grants at about $400,000 per year. Seven of the LTERs are biosphere reserves; consequently, these sites have very strong ecosystem programs.

Ecosystem research on biosphere reserves can be stimulated by several activities. First, baseline funding needs to be provided so that the essential monitoring programs can be carried out, permanent sample plots and exclosures established, etc., which will provide the required long-term data bases. Second, facilities and scientific cadres need to be created, thereby providing the infrastructure for research. Third, experimental approaches need to be expanded, particularly in national parks and wilderness areas where scientific potentials have not been realized.

Ecosystem science is unusual in its ready application to practical issues. It is central to the solution of many, if not most, major issues in resource management. Rapid technological transfer is possible, and ecosystem science is remarkable in its relevance to emerging and often unanticipated issues. Hence, it is an outstanding investment in its societal returns and should be strongly stimulated in biosphere reserves, given the objectives of the Biosphere Reserve Program.

The biosphere reserve system has outstanding potential as an international network for scientific collaborations in ecosystem science. With appropriate investments and planning, it could make major contributions in the critical areas of synthesis and comparative analysis. Very substantial efforts and funding will be required to achieve this potential, however.

BIOSPHERE RESERVES AND THE DEVELOPMENT OF SUSTAINABLE PRODUCTION SYSTEMS

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ABSTRACT. Biosphere reserves provide a unique linkage between development and conservation activities. If properly constructed, a national biosphere reserve program provides a direct mechanism for combining the best of conservation and even preservation activities with development. The conservation areas provide needed scientific baseline data and a feasible means for maintaining biological diversity. Associated developmental areas can provide useful experimental information for long-term maintenance of protected areas.

KEY WORDS: Biosphere reserves, biological diversity, sustainable development, resource management, cooperation, conservation, germplasm forestry.

Introduction

Much has been said and written about the value of biosphere reserves in the preservation and conservation of natural systems. From its very beginning, the Biosphere Reserve Program of UNESCO has offered a new dimension to the conservation field. The Biosphere Reserve Program has provided a scale of conservation management that previously was associated mainly with the national park concept. In fact, even today in many countries, the biosphere reserve and the national park concepts are often considered one and the same. It is all too easy to forget that the Biosphere Reserve Program is a vital element of the Man and the Biosphere (MAB) Program of UNESCO. This implies, and even states, the active role of man in the wise use of his environment. Unfortunately, too many natural resource management agencies and organizations fail to see or understand the value of the Biosphere Reserve Program to their own program. Unfortunately also, too many national MAB committees fail to involve development agencies in national MAB activities.

Resource Management

The Biosphere Reserve Program is a logical and rational link between conservation, and even preservation, with development. If properly constructed, this linkage can become mutually supporting.

As an operational example of how development and conservation can both be strengthened by a combination af activities through the biosphere reserve concept, I will review selected United States MAB activities, especially as they relate to the USDA Forest Service program.

During the course of the last 15 years, both Federal and State natural resource agencies in the United States have had to reevaluate their management priorities, their missions and their goals. The United States' society has been placing greater emphasis on conservation and the maintenance of what society considers natural systems. The United States has had a vigorous and professional national park system. At the same time, the United States has supported since 1905 a national forest system that was established to protect and manage Federal forest lands for an array of goods and services. These services include wood and wood products. But the USDA Forest Service is also a major provider of other goods and services, such as water, oil and minerals. It manages the largest recreation program in the United States and provides some of the best hunting and fishing opportunities in the United States, if not the world. Furthermore, it manages the largest wilderness program in the lower 48 states. As such, the USDA Forest Service manages one of the largest arrays of complex ecosystems with a richness of biological diversity that is unsurpassed. The maintenance of this rich natural diversity for current and future generations is the common goal of the land manager. The USDA Forest Service has a special responsibility to consider the long-term consequences of its management. To achieve Forest Service management goals requires an understanding of political feasibility, but also resource management limitations and a professional awareness and respect for scientific integrity in the fields of forest management and conservation. The Biosphere Reserve Program provides a direct mechanism for combining necessary conservation, and even preservation, activities with essential development programs in a self-supporting mixture. For these reasons, USDA Forest Service-managed experimental areas, wilderness areas and national forests compose elements of many of the U.S. biosphere reserves. This format provides a coordinated mechanism for scientists, conservationists and land managers to link and interact on resource management issues. It provides a direct means for information and data sharing.

Coordination and Cooperation

In the United States, the Biosphere Reserve Program offers a proven means of integrating distinctly different ownerships for the purpose of multi-purpose management. This enables various organizations to share their expertise and experience. Land use issues do not stop at an artificial boundary line; thus, managers benefit by cooperation. It should be realized at the outset that the U.S. program involves voluntary participation by land managers and, as such, the program does not infringe upon the individual manager's authority. Yet it provides the land manager with a wide source of technical expertise not found in any individual organization.

In the United States Biosphere Reserve Program, we have combined development, conservation and preservation activities in individual biosphere reserves by establishing core and buffer areas. Thus, the core or conservation area provides a baseline area against which to compare management practices. This arrangement makes it possible to establish parallel monitoring sites in which to carefully evaluate the consequences of management practices but also the changes that take place in protected areas. This mixture of developmental and protected areas contributes to the total mangement of complex systems that must serve many different needs.

Intensive forest management, to be successful, must have appropriate germplasm matched to the site environment; but there must also be an adequate level of basic ecological and biological understanding if the system is to be sustained over time. Again, the core area of the biosphere reserve can provide that source of basic ecological information for a given geographic region. To be useful, biosphere reserves must serve the needs of the people. They need not be solely for preservation activities. In the USDA Forest Service, preservation needs are recognized and are pursued at various scales from wilderness areas, which cover many thousands of acres, to smaller units such as research natural areas, botanical areas and special use areas. All of these various elements can make up a biosphere reserve and thus contribute to our scientific understanding.

Biosphere reserves offer a realistic means for the conservation of a genetic base for development projects. To be effective, a biosphere reserve must include an array and variety of forest ecosystems which are representative of the forest gene resource found in areas where forest management is, or will, be practiced. To meet long-term needs, forest gene resource management strategy must be dynamic. Since it is essential that patterns of environmental variation be reflected in the inherent variation of the gene pool, a broad range of environmental variation must be included. Another critical factor is size. The area should be sufficiently large to minimize the hazard of foreign pollen contamination. In addition, the full range of biological material should be found from stands of unique and exceptional growth and from stands in the transition or stress zones. The Biosphere Reserve Program, if properly established, can meet these essential conditions by combining an array of different landownerships. The Biosphere Reserve Program is a natural link between developmental management and conservation. All too often, these programs are considered as separate and distant activities. One cannot have long-term and permanent conservation without proper development. Nor can sustainable development take place without a realistic conservation program. In the Biosphere Reserve Program, properly established development and conservation activities are mutually supportive. For these reasons, many of the U.S. biosphere reserves are composed of selected national parks, or other conservation areas, and USDA Forest Service-manged lands. The system works because all organizations contribute and mutually benefit.

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BIOSPHERE RESERVES IN THE TROPICS: AN OPPORTUNITY FOR INTEGRATING WISE USE AND PRESERVATION OF BIOTIC RESOURCES

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ABSTRACT. From their formulation a century ago, ideas on the conservation of natural resources rested on two strategies: (1) protection and (2) manipulation of natural systems. In the United States these two strategies became polarized, each evolving into a movement of its own with different management philosophies, implemented by different government agencies. I argue that tropical countries cannot afford such a dual conservation strategy, because in the tropics human needs are more critical to the survival of people and natural resources, and because tropical countries lack sufficient financial resources to waste in needless duplication of effort. The biosphere reserve concept of the Man and the Biosphere Program offers the ideal framework to integrate conservation efforts in tropical countries. Experience with the Luquillo Experimental Forest Biosphere Reserve is reviewed to illustrate the dangers of extreme preservation ideas and confrontation tactics in tropical countries. Simultaneously, experience in Puerto Rico is reviewed to illustrate the responsiveness of tropical ecosystems to sound management practices. I call for a new conversation ethic for the tropics, and outline the elements of such an ethic.

KEY WORDS: tropical forests, conservation, Luquillo Experimental Forest, biosphere reserves, restoration, deforestation, tropics, Man and the Biosphere Program, MAB.

Although the acts of conservationists are often motivated by strongly humanistic principles, the practice of conservation must also have firm scientific basis or, plainly stated, it is not likely to work.
– David W. Ehrenfeld (1970)

When Ehrenield wrote these words, the popularity of the conservation movement was beginning to accelerate in the United States. The National Environmental Policy Act had just been enacted, the Endangered Species Act and Coastal Zone Management Act had not been written, the Man and the Biosphere (MAB) Program had not been launched, and the magnitude and consequences of tropical deforestation were known to only a few professionals in the field. Although the quote is as sound today as it was when written, many of the situations described by Ehrenfeld in his book have changed, some for the better, others for the worse. For example, water quality in the United States has greatly improved since the 1970s (Smith et al. 1987). The destruction of the Oklawaha River in Florida, which appeared imminent when Ehrenfeld described it in his book, was also averted by the Florida Defenders of the Environment under the leadership of the Carr family, to whom Ehrenfeld's book is dedicated. In contrast, the threat of destruction of tropical forests is perceived to be much more imminent today than it was in 1970.

In this paper, I will focus on Ehrenfeld's description of the evolution of the conservation movement in the United States because the movement has experienced 17 years of vigorous growth, and its influence is now global. With expansion into the global arena, conditions become more complex, both socially and ecologically, and it becomes necessary to examine the assumptions of the movement so it can function with the same vigor and success as in the United States.

Ehrenfeld summarized the foundations of the conservation movement in the United States around the works of George P. Marsh, Gifford Pinchot, John Muir, and Aldo Leopold. In his opinion, the intellectual foundations of the conservation movement can be traced to the following quote from Marsh: " . . . This much we seem authorized to conclude . . . the law of self-preservation requires us to restore the [natural] equilibrium . . . In other words, destruction must be either repaired by reproduction, or compensated by new destruction in an opposite quarter." Thus, from its origins, the ideal of conservation recognized its importance to human survival and rested on two strategies: (1) protection and (2) manipulation of natural systems. I use the term "conservation" in the same context suggested in the quote by Marsh.

Ehrenfeld followed the traditional convention of presenting the conflicts between the conservation ideas of Pinchot and those of Muir. Pinchot believed in using resources wisely, while Muir focused on their preservation. In fact, to this day the conservation movement is divided in concept and practice into these two points of view. However, over fifty years ago Aldo Leopold demonstrated the use of scientific principles for managing and restoring ecosystems. Through a lifetime of hard work, Leopold put into practice the second conservation strategy of Marsh. Leopold's methodology provided a tool for assuring wise use and preservation of resources, even after the balance of nature had been altered by humans. Today, one can visit the Arboretum at the University of Wisconsin and see restored examples of many ecosystem types typical of that part of the country. They are living proof of the resiliency of natural systems and of the feasibility of applying ecological understanding in their use while preserving their biological diversity.

The polarization of the ideas of Muir and Pinchot was unnecessary and unfortunate. Today we understand that the goals of resource preservation and wise use are both necessary and can be integrated in most plans of land development. This realization was already clear in the early work of Marsh and emerged again in the practical experience of Leopold. Manipulation, wise use, and preservation of resources are all vital parts of a conservation ethic and of any strategy of human survival on Earth. Optimum resource use can be achieved only when all aspects of the strategy contribute to the goal of conservation.

In the United States, the conservation of natural resources is made difficult by the pervasive gap between preservationists and resource managers. Part of this problem can be traced to the educational system that trains these groups in isolation. They are educated in separate faculties and are generally detached from one another even though both groups deal with the same resources. Those in each field of endeavor produce and read different scientific literature. As a result, professionals concerned with the conservation of resources develop different perceptions of what to do and how to deal with a given ecosystem. Often, preservationists and resource managers engage in endless courtroom arguments over the best strategy for the conservation of valuable natural resources. Ironically, many of these arguments are usually resolved by lawyers, economists, or engineers who lack sound understanding of natural phenomena. Biologists may be in both camps and thus cannot agree among themselves on the proper course of action or hesitate to testify on matters that their scientific training suggest are not "black or white."

This sad state of affairs works adequately in the context of a rich and sparsely populated country such as the United States, where institutions are strong, scientific talent and understanding is abundant, many alternatives for action exist, and resources are available for their implementation. For example, this nation created and maintains a National Park Service to implement the ideas of John Muir and a Forest Service to implement those of Pinchot. In developing countries, natural resources may be abundant, but the quest for basic human needs cannot be fully satisfied because their economic, political, and cultural systems cannot handle the large demands of dense and poorly educated human populations. As a result of these conditions and historical factors, the attitude of these societies toward their natural environment is different from that of the United States.

Given this situation, the conservation of natural resources in the tropics can little afford the polarization and double effort prevalent in the United States and must be approached from an integrated perspective rather than from polarized positions (c.f., Mares 1986). Below, I discuss how the biosphere reserve concept and the MAB program can be used to achieve such a goal and how they provide an opportunity to integrate the apparently irreconcilable conservation philosophies that divide resource management in the United States. In this paper, I will give examples of instances where well intended actions from polarized points of view have hindered rather than advanced the protection of natural resources.

Conservation in the tropics can benefit immensely from recent scientific advances and from lessons learned in the United States, with both polarized and integrated approaches to resource conservation. Given the alternatives available, the prudent strategy for the tropics should be integrated multiple use resource management. Integrated resource management in the United States is dictated by the Multiple Use-Sustained Yield Act under which the USDA Forest Service has operated for 27 years. This management agency has developed, through positive and negative experiences, useful approaches to sustainable resource management. It should be clear that sound principles of management are not inconsistent with total preservation of biological diversity. Principles such as these can only be transferred to the tropics by keeping in perspective that conservation activities in the tropics must be tailored to the needs of people and that transfer of our conflicts and differences is not part of the exchange. Transfer of conflicts or irrelevant technology will harm resources that deserve protection from ill-conceived human activity.

The Luquillo Experimental Forest Biosphere Reserve

This 27,846-acre (11,269-ha) Biosphere Reserve, also known as the Caribbean National Forest (LEF/CNF), has been studied in more depth than any tropical rain forest. Mosquera and Feheley (1984) listed 1,357 references on forestry research in Puerto Rico.

Brown et al. (1983) found that in addition to traditional descriptive and taxonomic research, the forest has been studied from an ecosystem perspective, including detailed studies of hydrology, climatology, and edaphology and of forest responses to management, human stressors, and periodic natural catastrophes.

Land uses of the LEF/CNF Biosphere Reserve and its surroundings follow the principles established for biosphere reserves (c.f., Batisse 1986), e.g., (1) a central core of 9,530 acres (3,857 ha) of virgin forests dedicated exclusively to preservation and research, (2) a concentric band of mature and virgin forests (10,411 acres or 4,213 ha) dedicated to preservation, research, passive recreation and education, (3) an outer band of managed and unmanaged tropical forests (6,565 acres or 2,657 ha) growing on lands previously used for agriculture, and (4) scattered public and private lands with various intensities of human use (Fig. 1). The LEF/CNF Biosphere Reserve has examples of all the functions of biosphere reserves suggested by Batisse (1986), e.g., (1) conservation and monitoring core, (2) buffers used for research, education, and tourism, (3) experimental research, (4) traditional uses, (5) rehabilitation of lands, (6) transition areas, (7) human settlements in the immediate vicinity, and (8) facilities for research, education, tourism and monitoring. In 1983, the government of Puerto Rico enacted zoning regulations assuring that uses in the immediate vicinity of the LEF/CNF Biosphere Reserve would be of low intensity, with increasing intensity of use at greater distances from the forest (Junta de Planificacion 1983).

The USDA Forest Service has been managing the LEF/CNF by using principles of multiple use for over 7 decades, essentially without controversy. During this time, the forest has sustained a rich diversity of plants and animals, including some of the most highly endangered species on the island, while also producing timber products, water, and recreation; supporting a profitable tourist trade; and offering many more amenities that rank the forest as the most visited and used forest area in the Caribbean (1.5 million visitors/yr).

In 1986, the Forest Service published a land management plan for the biosphere reserve (USDA Forest Service 1986). The plan outlined some uses of the forest that were objected to by the local government, general public, conservation groups, and members of the scientific community. Following a period of intensive public dialogue, demonstrations, and a legal appeal of the plan, the Forest Service withdrew its proposals for commercial timber harvesting and road construction and began work on an amended plan. Many lessons were learned from this process. The exercise underscored the importance of public review and involvement in the management of public lands and resources. Such involvement must be continuous through both the preparation and implementation phases of planning, and managers must be willing to disclose their management plans and submit them to public scrutiny.

In this example, public sentiment was clearly on the preservation side of the conservation movement. The agency responsible for management of the forest responded positively to public concerns, and the controversy is well underway to being resolved. It is not my intention to determine what is the best management for the LEF/CNF Biosphere Reserve. Instead, I want to evaluate the role of scientific information in this incident in light of the comments made in the introduction. These questions are addressed: Was correct information used when informing the public? Did science contribute in the formulation of alternative uses of the forest?

Figure 1 (next page). Map of the Luquillo Experimental Forest Biosphere Reserve (also the Caribbean National Forest) showing land uses and land use zones outside the forest as designated by the Puerto Rican Planning Board. The configuration and types of land uses in the Luquillo Forest conform exactly with those suggested by Batisse (1986) for biosphere reserves.

LUQUILLO EXPERIMENTAL FOREST-CARIBBEAN NATIONAL FOREST BIOSPHERE RESERVE

Table 1 lists all the objections expressed publicly on the Land Management Plan of the LEF/CNF Biosphere Reserve and also contains relevant facts taken from the plan. Clearly, public debate was not based on what the plan said but on assumptions of what it said. Because the plan was in English and Puerto Rico is a Spanish-speaking country, one could assume that these erroneous perceptions were due to a language barrier. However, in July 1987, 8 months after the Forest Service said it would amend the original plan, the Bulletin of the International Union for the Conservation of Nature (IUCN) published the article reproduced here as Fig. 2. In spite of IUCN's excellent reputation regarding its conservation strategy for tropical forests, this article contains six inaccuracies and attacks the credibility of scientific research conducted in the biosphere reserve.

Another argument used to object to certain types of research or manipulation of forest lands in the LEF/CNF Biosphere Reserve was the uniqueness of the forest. Daniel Janzen said in a letter dated September 25, 1986, to the Chief of the Forest Service that "There is absolutely no other forest on earth like that [Luquillo] forest in species, species combinations, and ecological processes. On a trade basis, its approximately 20,000 acres is easily worth 200,000 acres of extremely species-rich Brazilian rainforest." In response to these arguments, a group of scientists proposed the formation of an overview committce to assure that research in the LEF/CNF Biosphere Reserve would be ethical and that it would not result in forest destruction. The committee suggested that any experiment or manipulation not explicitly covered in the management plan, that results in the reduction of more than 1 m^2/ha of basal area, would require their review.

Arguments such as these received wide media coverage and were sufficiently strong to persuade a private funding agency to withdraw support for volunteers to help on an inventory of trees because such inventories "would help the Forest Service destroy the forest."

Based on numerous media and other public communications, such as the examples given above, I conclude that the content of the plan was not used in the public debate by opponents of the plan, including the scientific community. Science was used to promote preservation, even at the cost of research, which is the basis of conservation. Scientists were eager to police other scientists to avoid expected unethical experiments and obstructed research proposals, regardless of scientific merit. The result of the exchange was an atmosphere of confrontation rather than that of constructive dialogue or of a search for alternatives.

A strategy used with success in the United States is to exaggerate the precariousness of the biotic or environmental condition and highlight the uniqueness of the ecosystems involved, thus appealing to emotion. Perceived goals of conservation or preservation are achieved by placing extreme pressure on government or management agencies, attacking their credibility and causing confusion. Tactics and strategies for the conservation movement are presented in terms of "armies," "battles," "retreats," "rearguard actions," "casualties" and "enemies" (c.f., Ehrlich 1980). These tactics are not designed to resolve conflict; they cause it. Should these tactics be extended into the tropics and will they work? Are they helpful? The answer to both questions is no. The success of such tactics is only temporary. Over the long term they taint the image of conservation when the public becomes aware of the delusion and the biased consequences. More importantly, these tactics harm the credibility of agencies trying to manage resources for the benefit of people. In the tropics, where such agencies are extremely weak to begin with and where unfulfilled human needs are so important, resource conservation will be the loser if confrontation is the tactic used.

Table 1. A list of objections to the Land Management Plan of the Luquillo Experimental Forest/Caribbean National Forest. These objections were expressed by the public at large through various fora.

Reason for objecting	Notes from the plan
The region will be deforested.	The plan called for a maximum cut of 123 acres/yr, followed by forest regeneration.
The forest will be destroyed.	All cutting areas will be regenerated. All cutting was to be on sustained yield basis.
Crown lands will be affected.	Crown lands are preserved in their original condition (Fig. 1).
21% of the forest will be destroyed.	The U.S. Fish and Wildlife Service has not designated the critical habitat of the parrot, and they endorsed the management plan after a consultation with the Forest Service.
Species diversity will be reduced.	Increased protection will be given to rare, threatened, and endangered species.
Endangered species will be affected.	The plan considered all threatened and endangered species in the forest. None is affected by proposed actions.
Native species will be substituted by exotic species.	Mahogany trees already planted in degraded areas of the forest will be managed for timber production.
Water, soil, and air will be affected.	
Erosion will occur.	
Noise will be produced.	
Too much human activity in a fragile area.	
Too many roads are to be constructed.	The plan proposed 21.5 miles of roads over a 50-yr span.
The forest does not require management.	

Table 1. (cont'd)

Reason for objecting	Notes from the plan
The venture is not economically feasible.	Public demand for forest goods and services is well documented.
The plan does not resolve anything.	
Adequate publicity was lacking.	Public hearings, town meetings, radio, newspapers, TV, and a mailing list were used over a 5-yr period to give publicity to the plan. The plan was published in draft format and public comments solicited.
The plan was in English rather than Spanish.	A Spanish summary was published.
The plan is designed to take the wood elsewhere while leaving the pollution in Puerto Rico.	The plan does not stipulate where the wood will go.
The plan is a front to promote military use of the forest.	False.
The plan is an American strategy to exploit the forest.	
This is a unique forest.	
The plan lacks an adequate technical analysis.	
-Private industry will make a profit.	Private industry is encouraged to harvest timber lands.
-The plan is deceptive.	

Chain-saws in the Forest

According to the Sierra Club, a storm of
public protest has resulted in the U.S. Forest
Service modifying a plan to start a "model"
(1) commercial timber operation in Puerto
Rico's largest remaining virgin forest.

However, the danger is not over.

In 1986, the Forest Service unveiled its
50-year management plan for the 11,000ha
Caribbean National Forest. It called for tim-
(2) ber harvesting more than 20 per cent of the
forest although there is no commercial mar-
ket for the wood. (3)

The Forest Service justified the proposal
by saying "the U.S. needs to show depressed
(4) Third World countries that tropical forests
can be commercially tapped while largely be-
ing preserved". The Caribbean National
Forest was designated a Biosphere Reserve in
1976. The Forest Service found itself facing
an array of angry conservationists and Puer-
to Rico's delegate to the American Congress.
He introduced legislation calling for the pro-
hibition of commercial timber harvesting.
(5) The Government of Puerto Rico and the
Forest Service now say they have "modi-
fied" their plan but they have not revealed
what the new plan is and conservationists
fear the modified plan will call for the same
(6) amount of timber to be cut for "research"
purposes. □

Figure 2. Article that appeared in volume 18(4) of the Bulletin of the International Union for the Conservation of Nature. Numbers in the margins identify factual inaccuracies in the article: (1) Not a single acre of the approximately 15,000 acres of virgin forests in the reserve will be harvested (Fig. 1). (2) The plan calls for an annual harvest of 123 acres; the article implies all commercial lands will be harvested. (3) Puerto Rico imports 400 million U.S. dollars a year in wood products, quite a market! (4) The quote does not appear in any official document of the Forest Service; pages 4-58 of the plan (USDA Forest Service 1985) provides a different reason for commercial logging. (5) The government of Puerto Rico has no jurisdiction over the Luquillo Forest and has never claimed responsibility for U.S. Forest Service actions in Puerto Rico. (6) This prediction of the future has no basis and ignores the value of research for conservation.

Examples of this kind of confrontation are already common. The incident with the LEF/CNF Biosphere Reserve is one example. On a global basis, exaggeration of tropical deforestation rates by Myers (1980), inflation of the magnitude of potential numbers of species extinctions (reviewed by Lugo 1987), and of the amount of carbon dioxide given off by deforested tripical lands (the review by Houghton et al. 1985 reduces commonly quoted values by a factor of 5), create a collective hysteria in which people are willing to adopt measures that may in fact squander needed time and resources to focus attention in proportion to the true seriousness of these and many other problems.

Many of us believe humanity has time to solve its ecological problems if it tries hard enough (Mares 1986). However, if communication is forbidden because some sectors of society belong to unfriendly "armies," and worse yet, if we believe that ecosystem restoration is impossible and that growth of human population precludes conservation (first and second laws of conservation, *sensu* Erlich 1980), then it is useless to even consider conservation as relevant to the developing tropical world.

I do not have such a pessimistic view of the situation in the tropics. I believe that, through a coordinated effort by all professional sectors of society, we can mitigate and perhaps reverse some of the senseless waste of natural resources now taking place in the world. If humans take the necessary steps, natural systems will respond; they have proven resiliency and capacity for recovery from all kinds of stressors (c.f., Lugo and Brown 1986). Clearly, altered and unfamiliar ecosystems will result from many such human efforts, but their functions and services will be analogous to those they replace. Restored and managed systems are our best tool to slow down destruction of primary forests. They provide needed services near human populations, reducing the need to search for these products and services in remote areas, and thus directly contribute to forest preservation. Techniques of restoration, rehabilitation, reintroduction, and creation of ecosystems allow humans to heal damage to the biosphere (Bradshaw 1977). As tools for conservation, they are as effective as sterile outcries for ecosystem preservation.

Iltis (1983, p. 60) assumes that anyone who favors restoration and forest management or worries about the credibility of conservation is "utilitarian" and "anti-preservation." Not so. Iltis and others apparently do not understand the enormous implications to conservation strategies, of whether there is a 0.6%/yr rate of forest loss vs. a 2%/yr rate of loss. In fact, at a 2%/yr loss, forests would disappear in 50 years, assuming that area lost remained constant, but at 0.6%/yr there would be 167 years to do something about it before all forests were lost. Such mismanagement of numbers is devastating to the successful conservation of tropical forests. It led Mares (1986, p. 736) to remark in response to a similar posture by Soule (1980) that "It is inadvisable for scientists to consider data a luxury, for such an attitude can lead to errors in judgment." In the case of preservationists like Iltis, the errors in judgment rest in their inability to suggest any feasible solution to the enormous problem they describe while being willing to lead the developing world through a path of inaction and certain catastrophe.

I agree with Ehrlich (1980) in the assessment that human survival is at risk if strong conservation measures are not adopted by all nations of the world. It is also true that much of the destruction of tropical resources is due to political and economic policies and legal systems that have little to do with satisfaction of human needs (Porras and Villareal 1986; Schmink 1987). These tragic realities, however, make the situation more complex and demand as much attention as preservation *per se*. They present another reason why exaggeration is so serious in leading to the spending of energies on matters that do not require so much attention at the moment. Conservationists with realistic understanding of the situation in the tropics and with new ideas on how to deal with these problems should come forward and help educate the public so that the few financial and human resources available can be used with maximum effectiveness.

The Need for a Conservation Ethic for the Tropics

If conservation is to be successful in the tropics, it must adhere to the highest standards of scientific rigor and human ethics. The introductory quote from Ehrenfeld must be the guiding principle of the effort to conserve some of the least understood and most complex ecosystems in the world. More attention is needed on the human aspects of conservation. The movement must provide answers to the question: "How can people and natural environments survive in a crowded Earth?" The ideas of Marsh, Pinchot, Muir and Leopold must be meshed into a coherent strategy of survival. We know these ideas are not contradictory. They are all necessary for dealing with the complex problems faced by people in the tropics. To ignore this complexity in favor of tired slogans with doubtful value, even in the context of developed western countries, will only expose the irrelevance of that kind of conservation to the developing nations.

More understanding is needed as to the levels and limits of resiliency of natural ecosystems. Uninformed writers have painted a picture of the tropics that is rich in mythology and short on factual information (c.f., Lugo and Brown 1981). As a result, well intentioned people believe that tropical forests are so fragile that they require immediate fencing and protection from the hungry people of the world. Such suggestions are doomed to failure because they provide no real alternative for feeding, clothing, and housing people in need of resources (c.f., Leslie 1987). In fact, the use by people of national forests and national parks in the United States is what provides the grass-root impetus for their conservation and protection; it is no different in the tropics!

A conservation ethic for the tropics must include the following criteria: (1) people's needs, both in short- and long-term perspectives, (2) highest ethical and humanistic standards, (3) best scientific information available, (4) integration of preservation ideas with those of wise use and rehabilitation of resources, (5) education of people, (6) trust that well-informed people will make the right decisions about resource conservation, (7) working closely with local authorities and local people, (8) strengthening institutions dedicated to research, education, conservation, and administration of natural resources, and (9) elimination of mythology and shallow emotionalism.

The Role of the Man and the Biosphere Program

The only global program that is consistent in practicing a philosophy of resource preservation and wise use is the MAB Program. The MAB Program also offers a network of biosphere reserves to test ideas and resource-use alternatives. Biosphere reserves are excellent places for integrating wise use and preservation of tropical landscapes. A program under way in Jalisco, Mexico, like that in Luquillo, may be pioneering such integrations (Guzman Mejia and Lopez Zavala 1987).

To realize such a goal, dramatic efforts are nneeded by all sectors of society. In the tropics, there is a need for strengthening resource management institutions. Strong political backing is needed in each country. Research activity also needs a higher priority and a change in focus from taxonomy and evolution into a more holistic and integrated study of long-term phenomena in whole landscape units. The MAB program has recently outlined such a focus for its research program (UNESCO MAB 1986). The program places emphasis on ecosystem approaches to the study of human-impacted ecosystems. MAB encourages problem-solving studies that use multidisciplinary techniques. Inclusion of the human component is recognized as essential for the success of the program. These types of research approaches are needed to support any modern conservation strategy.

To better assure long-term success of conservation efforts, the education of resource managers and other biologists must overlap. Both professions stand to make enormous gains in insight if their training is well-balanced and integrated. Also, such integration of disciplines will lead to better understanding of each other and less adversarial postures in matters dealing with resource management.

To conclude, I quote Aldo Leopold (from Meine 1987): "This paper proceeds on two assumptions. The first is that there is only one soil, one flora, one fauna, and hence only one conservation problem. Each acre should produce what it is good for, and no two are alike. Hence a certain acre may serve one, or several, or all of the conservation groups. The second [assumption] is that economic and aesthetic land uses can and must be integrated, usually on the same acre. The ultimate issue is whether good taste and technical skill can both exist in the same land owner." This is a challenge to conservation anywhere, and it focuses on the task that the Man and the Biosphere Program is trying to accomplish in the tropics.

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COASTAL AND MARINE BIOSPHERE RESERVES

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ABSTRACT. Conservation, development, and logistic components of biosphere reserves are well suited for coastal and oceanic, resource and human use management. Particular emphasis is placed on the broad, productive coastal zone which includes coastal plains, continental shelves, and about 60 percent of humanity. A classification of environments is recommended as essential to perceive both the dimensions of human impact and the design of potential biosphere reserves. The biosphere reserve concept is especially appropriate for coastal and marine resource conservation and development. Pilot studies should be initiated to illustrate this concept.

KEY WORDS: Biosphere reserve, protected area, biogeography, environmental classification, coastal zone.

Introduction

Protecting environments from the onslaught of human exploitation and misuse is a challenging task on land, but it is even more so for coastal and marine waters. Protected areas are difficult to conceive for a number of reasons and the dominance of fishes and invertebrates does not create a basis for emotional public outcry. Yet, the very facts that the sea is so different from the land and that the coastal zone, almost everywhere on our planet, is crowded with people, force us to consider innovative mechanisms for its protection.

The concept of the "biosphere reserve" can fulfill this purpose. This concept has recently been expressed by Batisse (1986) and an Action Plan for Biosphere Reserves has been developed (UNESCO 1984). The concept involves conservation, logistic, and development components that are well suited to coastal and marine areas where jurisdictional boundaries are complex and where the activities of mankind are pervasive. This concept also is heavily weighted toward the research and monitoring that are essential for conservation, but which are relatively neglected in most protected areas.

A tripartite subdivision of Planet Earth into uplands, coastal zones, and open ocean can be recognized at the global scale. Coastal and ocean zones may be subdivided and mesoscale ecosystem units can be defined, both physically and biotically. These subdivisions have the characteristics of functional ecological units, driven by characteristic ecological processes; they also possess characteristic biota and habitats. We emphasize the broad, productive area of Earth called the coastal zone. This is not to say that the deep ocean beyond is not important, but that coastal zone conservation is particularly urgent. Also, the recognition of the full extent of this zone is fundamental to both land and sea resource and human use management.

The Coastal Zone

The narrow, intertidal zone is an obvious division between land and sea. It is surely an ecotone at the local, microscale level. On the larger meso- or macroscales of regional to global ecological processes, however, this division is not ecologically realistic. As Ketchum (1972) and Hayden, Ray and Dolan (1984), among others, have pointed out, the coastal zone is a major component of Earth. It comprises land-continental plains and sea-continental shelves, covering about 8% of the Earth's surface--the size of an Africa and a half! This zone is the most productive and ecologically diverse portion of our planet, and in many ways, the most disturbed.

Within the coastal zone, "production, consumption, and exchange processes occur at high rates of intensity. Ecologically, it is an area of dynamic biogeochemical activity but with limited capacity for supporting various forms of human use" (Ketchum 1972). This capacity will vary with geographic location, sensitivity, and with intensity of use, and our understanding of it demands recognition of ecosystem differences with latitude, longitude, and biota.

The Nature of Human Impact

The world's human population is about 5 billion and may double in less than a century. The highest density and numbers of people and the highest rates of population growth all occur in coastal areas. This implies a high degree of human impact. For example, freshwater demands will alter natural river drainage patterns and affect the quality and quantity of water that reaches the coasts (U.S. Water Resources Council 1978). Increased needs for protein will place even more pressure on finite fishery resources; already over half the population in developing countries obtains 40% or more of its animal protein from fish (World Resources Institute, 1986). Domestication of marine organisms for mariculture will further alter the structure of naturally productive estuarine and coastal waters, leading to loss of biological diversity in marine and coastal communities, just as animal domestication has on land (Coppringer and Smith, 1984). The domestication of continental shelf waters could also have severe consequences for global biogeochemical cycling (Lovelock 1979).

Wastes and pollution from every kind of human activity, from the atmosphere, run-off, and dumping, have been reaching coastal and oceanic waters for decades, and the rates are apparently increasing. In the U.S. alone, 50 million tons of waste per year is estimated to enter coastal waters, mainly from dredged material but also from industry, sewage, and other sources (Bierman et al. 1986). In addition, erosion of land is increasing sediment transport to many coasts. The persistent litter of humanity is abundant on the ocean floor (*Mar. Poll. Bull.* 1987).

In sum, the magnitude of human activities on the global coastal and ocean zones is nothing short of spectacular. We seem to be embarked on a global expriment to see how much abuse our coasts and oceans can take before we recognize that this vital segment of the earth requires our attention. The most obvious conclusion is that simply setting small areas aside from human activities cannot be a realistic approach to conservation or management.

The Dimensions of Human Impact

Defining the capacity of coastal and oceanic waters to assimilate perturbations has proven difficult and demands understanding of the dimensions of ecological units. A taxonomy of coastal and marine environments would aid our understanding of human impact. The macro-, meso-, and microscale divisions of coastal and ocean zones bring into focus the kinds and magnitudes of ecosystem units affected by various forms of use. However, we are misled by our senses that the land is obviously degraded by human influences, but that the oceans are relatively unabused. Most of us see only the water's surface, and the subtle changes occurring beyond our perview seem relatively minor. Considering the water's edge as a boundary further misleads our perception of impact.

Nevertheless, we are beginning to identify abused coasts and oceanic waters. In certain segments of the coastal zone, we can identify diseased fish and invertebrates; we find fishery stocks depleted and certain species gone; we can identify pollution; and our public health officials demand closure of beaches and coastal waters to protect human health. Also, the land or adjacent ocean may be altered, enhanced, or despoiled by the interchanges of oceanic and terrestrial processes. However, unless the similarites and differences among geographical and ecological units are recognized, management will be unable to anticipate impacts learned from similar environments.

A Taxonomy of Coastal and Ocean Areas

An emphasis on ecosystem representativeness demands identification of units derived from a hierarchical environmental taxonomy. Identification and selection of biosphere reserves requires recognizing appropriate time/space scales, most valuable conservation areas, and the nature of impact that coastal societies have on ecosystem integrity.

Defining conservation or management units may be accomplished in several ways. The most common method has been the identification of biogeographic units, i.e., the description of species or species-assemblage distributions (e.g., Udvardy 1975). However, this method has limitations: principally, it is not ecosystemic in the sense of describing units driven by discrete ecological processess. Meeting this latter requirement requires the recognition of both biological and physical controlling mechanisms.

At the global, macroscale level, Hayden, Ray and Dolan (1984) have summarized the state of the art for classification of coastal and ocean environments (Figure 1). Ocean and coastal realms, marginal seas and marginal archipelagoes, and biotic provinces are shown to be divisible into a classification whereby representative biosphere reserves may be selected at a global scale. This system of classification is but a first step, however, as its very large subdivisions can be described as ecosystems in only the most general way.

The next level in classifying coastal and marine environments is at the regional mesoscale, that is within physical or biotic provinces, in which the subunits more readily fall into functional ecosystem boundaries. Ray and Hayden (in press) begin with the concept of the watershed and extend this concept to marine waters to illustrate how terrestrial watersheds and marine "seasheds" interact (Figure 2). The terrestrial watershed boundaries are relatively easily delineated by topography and hydrology, but the marine boundaries are relatively difficult to define. Controls, some of which are

LEGEND

<u>Ocean Realms (Currents)</u>

- I Arctic
- II Subarctic
- III Variable eastward
- IV Weak and variable
- V Trade wind
  - e - strong equatorward
  - w - westward
- VI Strong westward and equatorward

<u>Coastal Realms</u>

- A Arctic - Subarctic
- B Western temperate
- C Western subtropical
- D Western tropical
- E Western intertropical
- F Eastern temperate
- G Eastern subtropical
- H Eastern tropical

<u>Biotic Provinces</u>

1. Arctic
2. Acadian Boreal
3. Virginian
4. Carolinian
5. Louisianian
6. West Indian
7. Caribbean
8. Brazilian
9. East Atlantic Boreal
10. Lusitanian
11. West African

<u>Marginal Seas</u>

Defined and named according to adjacent Ocean Realm.

Figure 1. Classification of North Atlantic coastal and marine environments (after Hayden, Ray and Dolan, 1984, with modifications for arctic and subarctic realms after Dunbar, 1985). This is a symbolic representation, not drawn to scale, especially for coastal realms. Ocean realms are for surface waters only. Coastal realms are highly variable, especially for temperate areas, which contain attributes of both subarctic and subtropical coastal waters.

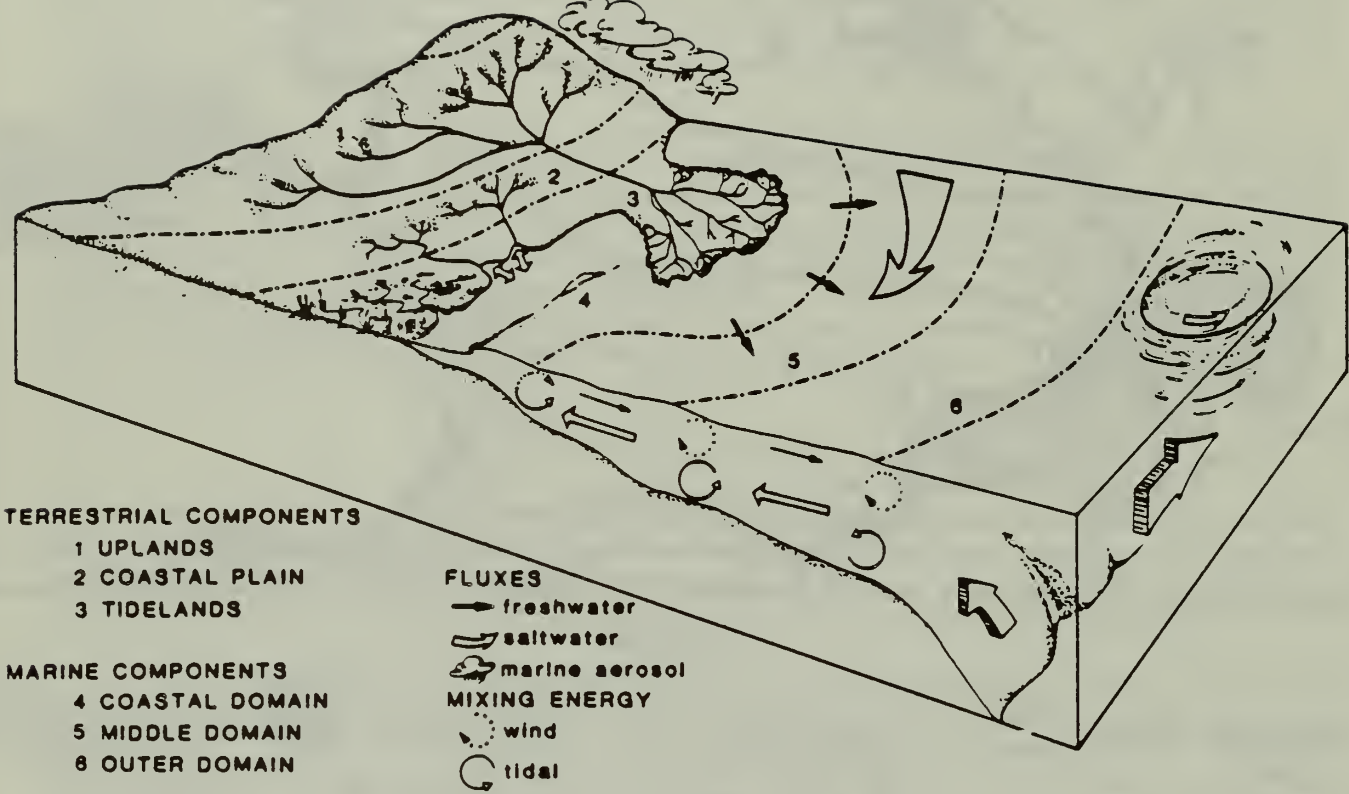


Figure 2. The coastal zone consists of terrestrial and marine components. These components are tied together functionally by various processes; some fluxes and mixing energies are illustrated. Biotic processes are also important; for example, the movements of organisms to and from continental shelf waters, estuaries, and rivers.

Three types of coastal units are illustrated: (1) a tidal unit consisting of the coastal domain and tidelands, (2) a river-estuarine unit in which interactions with both the coastal and middle domains are possible, and (3) a large watershed-deltaic unit with interchanges mostly with middle to outer marine-shelf domains.

illustrated in Figure 2, must be addressed in detail to define entire land-sea units.

Three characteristics of this mesoscale-unit definition must be noted. First, the individual unit boundaries may be variable and mobile in space and time, especially on the marine side. For example, currents and water masses are highly dynamic even though they do exhibit predictable characteristics. Second, units with similar functional characteristics may vary in size: small and large watersheds with high water flow volumes may contain similar faunas and may require similar management procedures. Third, there are watersheds within watersheds, according to the scale addressed; this leads to the conclusion that there is a nested hierarchy of ecosystems, again determined by time and space scales.

Finer scales of taxonomic resolution are referred to as "site-specific" or microscale. These are at the habitat level. Most protected areas and the bulk of environmental litigation are at these smaller scales of resolution. The effect, inevitably, of limiting resource conservation to this scale is loss of species diversity and impairment of ecosystem function.

The result of environmental classification is a taxonomy of environments. The next step is identifying ecological processes important to conservation and management. Most importantly, these processes are essential in describing the dimensions of biosphere reserves, which, for coastal and marine systems, can be very large!

Concepts of Protection

In the face of human perturbation, the first thing that comes to mind is protection, more often than not the setting aside of resources or areas. Historically, this has taken three phases. First, species or species' populations or areas of special interest were designated as protected by various mechanisms. As sophistication grew, the importance of habitat was increasingly recognized: species require habitat, and habitats were judged rich by the diversity of their species. Even later, as ecology flowered, the ecosystem was recognized as the proper emphasis for management, and ecological processes received attention. The ecosystem emphasis caused the recognition, also, that most protected areas are too small to maintain species diversity. In addition, an emphasis on ecological processes has mandated the inclusion of human-influenced processes into the equation of conservation. Indeed, protected areas must now consider not merely species biology and ecosystem ecology, which is difficult enough, but human economics as well! This leads inescapably to the concept of the biosphere reserve.

If biosphere reserves are a good idea for terrestrial areas, they may be essential for coasts and oceans. An example of the use of the biosphere reserve approach is Australia's Great Barrier Reef Marine Park Authority. Though "Park" is in the title and the emphasis is on protection and integrated use, the Authority is systemic in scope, from both ecological and economic points of view. Various zones are designated for science, replenishment, recreation, preservation, and various human (including commercial) uses. Nevertheless, the Great Barrier Reef is fortunate: human impacts there have not yet become severe.

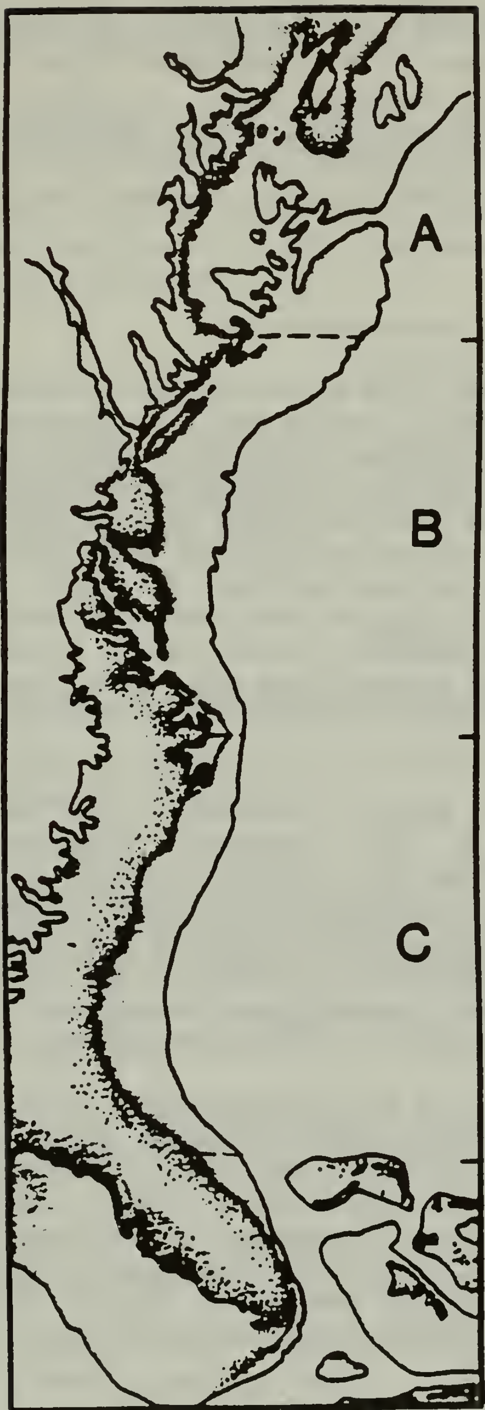
Salm and Clark (1984) have presented a summary of marine and coastal-protected areas as a "guide for planners and managers." Unfortunately, it is not detailed enough ecologically to guide the selection of representative protected areas. Nor can it be used for the design of scientific or monitoring programs, for fishery maintenance, or for resource management. Its principle purpose is that of promoting protection of species and habitats and providing for compatible human use. The biosphere reserve concept is not sufficiently explored.

The U.S. Congress has recognized a need for establishing marine protected areas. The 1984 amendment of the Marine Protection, Reserach, and Sanctuaries Act of 1972 emphasizes "wise use of the marine environment," in which "scientific research on, and monitoring of, the resources of these marine areas" shall be carried out. It provides authority for "comprehensive and coordinated management . . . that will complement existing regulatory authorities." The essential criteria for selection of areas are: "national significance," "size and nature that will permit comprehensive and coordinated conservation and management," "biological productivity," "biogeogeographic representation," "maintenance of the area's resources," and that each area be "identified as a discrete ecological unit with definable boundaries." A number of U.S. Marine Sanctuaries now exist, but it is fair to say that none fully meet these requirements. Most are very small and, again, emphasize protection. Resource mangement plays only a comparatively minor role.

Case Study: The United States East Coast

Ray et al. (1981) present a method for identifying and selecting coastal biosphere reserves based on biogeography, habitat diversity, and ecological processes. Scientific panels have been convened for each of the three regions of the U.S. east coast (Figure 3), i.e., the Acadian-Boreal, the Virginian-Mid Atlantic, and the Carolinean-South Atlantic. The principal difference among these regions is the nature of land-sea coupling; the first is dominated by oceanic processes, the second by estuarine processes, and the third by terrestrial processes. These differences strongly influence the nature of biosphere reserve design and implementation.

Through the work of special selection panels convened by the U.S. MAB Program, biosphere reserve sites have been nominated, or candidate sites are being reviewed, in all of these regions, based on their ecological merits, their representativeness of regional features, and other MAB criteria. Each panel's recommendations reflect differences in regional characteristics. For example, in the Carolinean-South Atlantic Coastal Region, existing protected areas suitable as core areas include representative coastal ecosystems almost in their entirety; only intercoastal and nearshore waters remain problematic, as jurisdictions change below the mean high water level. In contrast, the Virginian-Mid Atlantic Coastal Region is dominated by large estuaries with strong links to offshore waters. Ecosytems are, therefore, much larger and involve more complex human uses. Also, fewer strictly protected areas of large size exist that could adequately serve as core areas for biosphere reserves. For example, the core areas and associated buffer zones of a Chesapeake Bay Biosphere Reserve could include various small areas already legally protected through ongoing private, state and federal programs. The open-ended boundaries for the transition areas could derive from existing research, conservation, and management programs. Research, education, and restoration in the latter would be essential and could serve as logistic examples for the Biosphere Reserve network worldwide. MAB's endorsement could provide an important symbolic umbrella for further conservation and sustainable use in the Bay.



A. ACADIAN - BOREAL

1. Ocean-dominated
2. Dissected shelf with basins and canyons
3. Strong tidal mixing
4. Rocky shores: glacial history
5. Narrow coastal plain
6. Small barriers: many islands
7. Few long rivers
8. Small bays, coves, pocket beaches
9. Cool temperatures
10. Influenced by Labrador Current

B. VIRGINIAN - MID ATLANTIC

1. Coastal/ocean-integrated
2. Wide, flat shelf with canyons
3. Mixing of coastal and offshore waters
4. Extensive wetlands and lagoons
5. Rolling coastal plain
6. Extensive barrier beaches
7. Extensive river drainages
8. Very large estuaries
9. Variable seasonal temperatures
10. Influenced by Gulf and Labrador currents

C. CAROLINIAN - SOUTH ATLANTIC

1. Terrestrial-dominated
2. Wide, flat shelf; no canyons
3. Coastal waters variable and turbid
4. Poorly drained tidal marshes
5. Broad, flat coastal plain
6. Extensive barrier beaches
7. Long, silt-laden rivers
8. Small lagoons and estuaries
9. Warm temperatures
10. Influenced by Gulf Stream waters

Figure 3. The eastern United States coastal zone provinces. The principal defining characteristics are listed in the legend. See text for further explanation.

The Acadian-Boreal Coastal Region represents still another level of complexity. There are many protected areas on islands and capes suitable as core and buffer zones, but these do not exist in offshore waters; most of this ocean space is now included in the U.S. and Canadian Exclusive Economic or Fisheries zones. In order to adequately represent the region, the panel concentrated on including diverse and productive offshore areas as transition areas, and identified existing onshore protected areas as core areas and buffer zones that would symbolically and administratively "anchor" the offshore areas within the biosphere reserve framework.

Conclusions and Recommendations

The concept of a "wilderness sea" appears to be an anachronism. Oceanic and coastal waters have been receptacles for civilization's wastes and their resources have been abused. Widespread impacts of a growing human population demand mechanisms to protect the vitality of ocean and coastal zones. A plethora of regulations exists for management of coastal and ocean resources, yet it is notable that almost none are based on defensible ecological boundaries or on physical-biotic units. Many marine protected areas have been implemented, but the same problem also exists for them. Boundaries for coastal and ocean management regimes (e.g., the territorial seas) are mostly set by legal and economic constraints. The limited knowledge of these systems is also an impediment. Nevertheless, the biosphere reserve concept does offer an encouraging way to address these problems, so long as a framework for cooperation can be set up that reflects ecological boundary conditions.

Biosphere reserves offer a flexibility of design, in constrast to the "hard" lines that separate conservation and development in other resource management categories. Biosphere reserves also provide a useful vehicle to focus attention on conservation, science, and economic activities, including traditional uses, together. Finally, they offer a framework for local, regional and international cooperation. Of global importance, the biosphere reserve concept forces <u>systemic</u> thinking and action; it tends to break down the boundaries between social forces and to treat conservation and development together. No other resource management or conservation concept is equally integrative.

The MAB Biosphere Reserve program has been extaordinarily successful in many respects, but it has so far focused little on coastal and ocean systems, despite the predominance of these systems over the Earth and the proportion of the human population in the coastal zone. Furthermore, the 1986 meeting of MAB's Intergovernmental Coordinating Council pointed out that no "model" biosphere reserves exist that successfully take into account the total design of core-buffer-transition, or of conservation-development-logistic functions. We suggest that the time is ripe for developing such models and that hardly a better locus could be found than the coastal zone. We therefore recommend that:

1. The biosphere reserve be adopted as the appropriate concept for demonstrating the value of conservation and harmonious uses of coastal and ocean zones;

2. The coastal zone and the oceanic zone be recognized as fundamental planning units for biosphere reserves at the global level;

3. A global classification of coastal and marine environments be undertaken, in

accordance with the Action Plan for Biosphere Reserves, for the purpose of selecting representative ecological areas worldwide;

4. MAB, at national and international levels, seek to establish support programs, for the coastal zone in particular, to supplement terrestrial programs now underway; and

5. The application of open water biosphere reserve zonation be given special attention, and that pilot studies be implemented to illustrate these biosphere reserve concepts in coastal and marine areas.

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William P. Gregg, Jr. of the U.S. National Park Service and James M. Broadus of Woods Hole Oceanographic Institution offered many helpful criticisms. Judith L. Peatross of the Department of Environmental Sciences, University of Virginia, innovatively created the illustrations for Figures 2 and 3.

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THE SANTEE DELTA-CAPE ROMAIN UNIT OF THE CAROLINIAN-SOUTH ATLANTIC BIOSPHERE RESERVE

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ABSTRACT. The Carolinian-South Atlantic Biosphere reserve was the first coastal reserve to be established in the U. S. Man and the Biosphere program. It consists of three units: the Outer Banks Unit in North Carolina, the Santee Delta-Cape Romain Unit in South Carolina and the Sea Islands Unit in Georgia. This paper features the South Carolina unit. Located in the north-central portion of the South Carolina coast, it consists of approximately 48,000 ha of extensive salt marshes, ten contiguous beach ridge barrier islands and numerous tidal inlets. Special features include: the most significant river delta on the Atlantic coast of the U.S., a true embayment, a cuspate foreland, and extensive marsh impoundments formerly used for rice culture. Regional resource uses and management issues involved with this reserve are: rediversion of the Santee River, dredging and filling, management and use of impounded marshes, and beach stabilization projects. The way in which each of these factors impinge upon the value of this productive ecosystem for commercial and recreational fisheries, wildlife, and research are the focus of cooperative approaches among various agencies and groups involved in the reserve.

KEY WORDS: Biosphere reserve, South Carolina, coastal impacts and issues, wildlife management areas, rice cultivation.

Introduction

The Santee Delta-Cape Romain Unit is located at N 33°07'; W 79°20', in the north-central portion of the South Carolina coast. The lands are owned by four administrators: the U. S. Fish and Wildife Service, the State of South Carolina, the Nature Conservancy and the Belle W. Baruch Foundation. The South Carolina Unit encompasses about 75 km of coastline and is probably the most extensive, undeveloped area on the east coast of the United States (Figure 1), with long-term ecological research, conservation and wildlife management as its primary functions. On the western border of the reserve, but not included in it as yet, is the Francis Marion National Forest, consisting of 80,970 ha of upland pine, mixed pine and bottomland hardwood forests. The Atlantic Ocean borders the east side of the reserve. To the north and south are resort communities associated with the cities of Georgetown and Charleston, respectively.

This coastal area is especially rich in diversity of endangered and threatened species of animals. There are also numerous species of special concern, such as waterfowl, colonial nesting sea birds and wading birds.

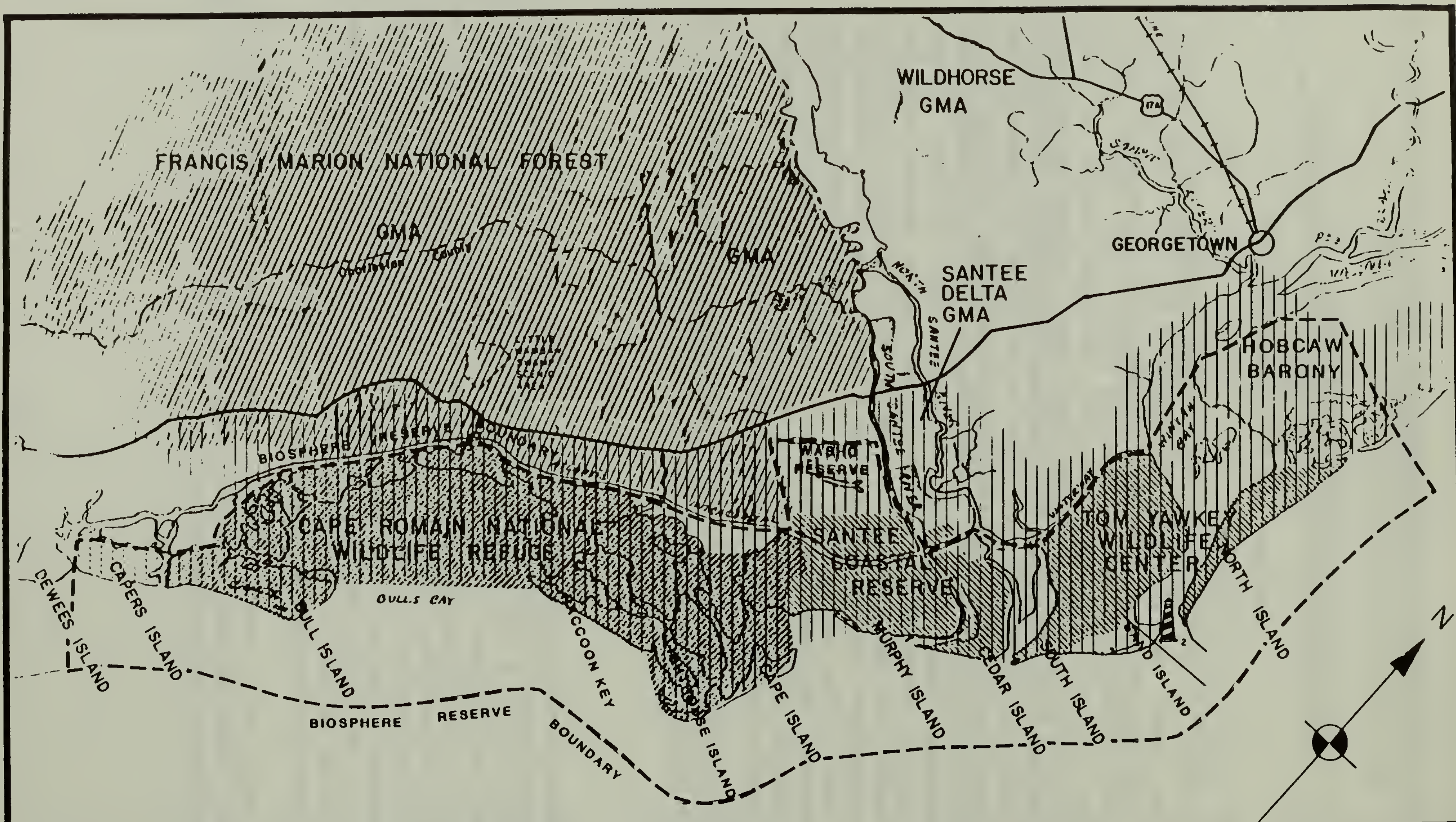

Figure 1. The Santee Delta - Cape Romain Unit of the Carolinian- South Atlantic Biosphere Reserve.

History

Historians believe that it was on this site in 1526 that 600 men landed to attempt the first Spanish settlement on the American continent. But disease and dissension plagued the settlers, and in 1527 only about 150 survivors returned home to Hispanola, Santo Domingo. In the 17th century, English influence increased along the Carolina coast and the land that is now Hobcaw became part of a vast colonial estate, the Carolinas, originally granted to the Lords Proprietors in 1665 by King Charles II of England. In 1718, King George III rescinded the grant to the Lords Proprietors and created baronies of 12,000 acres each, one of which was granted to Lord Carteret, who named it Hobcaw (Vernberg 1985).

During and after the colonial period, Hobcaw was further divided into as many as 13 plantations, two of the most noted being Bellefield and Friendfield Plantations. The area flourished on rice culture from about 1790 to 1890, bringing fortunes to many. In 1905, Bernard Baruch, a young Wall Street millionaire, began piecing the original Barony back together with the purchase of 12,500 acres, adding 5,000 more two years later. In 1958, the sprawling lands were acquired from Mr. Baruch by his daughter, Belle. During her last years, Miss Baruch spent considerable time in thought and planning over what would become of the property after her death. Belle Baruch's dream was established by her will in 1964. It specified that the property and net returns from the Belle Baruch Trust be used "for the purpose of teaching and/or research in forestry, marine biology, and the care and propagation of wildlife and flora and fauna in South Carolina, in connection with the colleges and/or universities in the state of South Carolina." The will also provided for a foundation, later named the Belle W. Baruch Foundation, and for trustees to administer the property and trust in perpetuity according to the will. In 1968, the University of South Carolina and Clemson University established two institutes at Hobcaw Barony: one for marine biology and the other for forestry (Vernberg 1985).

Ecological Setting

All major coastal habitats of the Virginian Mid-Atlantic Province are represented on Hobcaw Barony. The primary research programs are associated with a 2,630-ha high salinity marsh-estuary at North Inlet. The *Spartina alterniflora* marsh is separated from the Atlantic Ocean by Debidue and North Islands and is bordered on the west by old-growth loblolly and longleaf pine forests. Wetland habitats include exposed and sheltered sandy beaches, intertidal mudflats and oyster beds, submerged algae beds, various types of benthic habitats, rock jetties and rookery islands. More than 1,200 ha of brackish and freshwater marshes, which were formerly cultivated ricefields, border the Winyah Bay side of Hobcaw Barony (Vernberg 1985).

Current Land Uses

North Inlet is among the few pristine salt marsh systems on the east coast, since it is relatively isolated and the surronding uplands are undeveloped. The estuary was designated a prime coastal ecosystem and included as an Experimental Ecological

Reserve. In 1981, the North Inlet system was selected as the only marine-estuarine site in the nation to be part of the Long-Term Ecological Research (LTER) Program of the National Science Foundation.

The LTER program involves 23 principal investigators who are concerned with biological, chemical, and physical components of the North Inlet estuarine-marshland ecosystem. Full-time LTER technicians and three principal investigators are located at the field laboratory. Visiting investigators are encouraged to meet with the staff and examine the data base.

Over the past 18 years, the Baruch Institute has published more than 685 papers and books on studies conducted in North Inlet. The Belle W. Baruch Library in Marine Sciences, a publication by the University of South Carolina Press, consists of symposia publications related to coastal marine subjects; 17 volumes have been published (Brenneman and Blinn, eds., 1987). In addition, the Belle W. Baruch Foundation also sponsors short courses, coastal ecology classes, teacher workshops, field studies for interested groups, and guided tours of the site. The forest and marshes of the Barony comprise part of the northern core area of the biosphere reserve.

The Belle W. Baruch Forest Science Institute of Clemson University conducts research and management on the upland portion of Hobcaw Barony. There are four faculty and a forest manager. Research activities include: an allelopathy study between the loblolly pine and Chinese tallow tree; an inbreeding study of loblolly pine to determine the effects of a known degree of inbreeding; a genetic study of the turkey oak population; a ground water study (now in its 12th year) to determine the quantity and quality of surface water flow into the marsh; and a study of the population dynamics of the fox squirrel. In addition to research, the Institute's wildlife ecologist manages the deer and feral hog populations. The Institute also conducts prescribed burning and monitors the forest for outbreaks of the southern pine beetle (Gresham, pers. comm.).

The Tom Yawkey Wildlife Center

History

Considered one of the most outstanding gifts to wildlife conservation in North America, the Tom Yawkey Wildlife Center was willed to the South Carolina Wildlife and Marine Resources Department in 1976 by the late Tom Yawkey. The Wildlife Center, located at the mouth of Winyah Bay in Georgetown County, S.C., embraces North, Sand, and South Islands and most of Cat Island. Composed of approximately 8,000 ha of marsh, impoundments, forest openings, ocean beach, pineland and maritime forest, the Center is principally dedicated to the management of habitat for the purpose of wintering large numbers and varieties of waterfowl.

From 1730 until 1861, rice planting was the economic base of Georgetown County. As the natural gateway to the port of Georgetown and upriver plantation homes, North and South Islands were critical locations for the community's defense. In 1789, Paul Trapier, a Georgetown planter who owned North Island, made a "gratuitous cession" of land to the federal government for a lighthouse on the bay. By 1801, one of the first lighthouses on the south Atlantic coast, the North Island Light, was in operation. Although the lighthouse suffered extensive damage in 1812 and 1867, it was rebuilt both times and stands as the oldest active lighthouse in South Carolina today and has been listed on the National Register of Historic Places since 1975.

Despite the War Between the States' stunning impact on the South's agricultural-based economy, many Georgetown planters attempted to continue harvesting rice. Crops were damaged by the ubiquitous rice birds or bobolinks--then were finally decimated by a series of hurricanes in the late 1800s. By 1910, rice planting in Georgetown had met its end. In the years from 1890-1930, the abandoned plantation homes were bought by northern industrialists.

In the late 1930s, Tom Yawkey began developing his property into a managed waterfowl refuge. In 1966, when Yawkey was 63, he shifted the greater burden of management responsibilities to his wildlife biologist. It was during the period between 1966 and 1976 that Yawkey encouraged the development of new scientific techniques in waterfowl and game management. Through Yawkey's sponsorship, his biologist was able to use the best to create the best. While some of the property remains in its natural state, some has been historically manipulated for rice or waterfowl. Other land has been altered in recent years for game management (Lumpkin 1979).

Ecological Setting

North Island is located at the entrance of Winyah Bay. It adjoins the Hobcaw Barony and is included in this core area of the biosphere reserve. Although North Island was often frequented by the Indians and the planters, it has always been quite isolated. The island has a sandy beachfront that is 12.9 km long and includes both high land and marsh. There is 0.4 ha of developed land supporting a U.S. Coast Guard Station. The remaining 2,440 ha are in an undeveloped state with no roads or trails. North Island is a Holocene beach ridge island with a maritime forest community. Elevations on the island range from sea level to 12.8 m at the top of the highest dune ridge.

Since the early 1900s, Sand Island formed at the base of the south jetty, the entrance of Winyah Bay. It is a low-lying island with no trees and consists primarily of dune vegetation.

South Island also has maritime forest and beach. A wide band of marsh, tidal creeks and impoundments separates the island from Cat Island to the west. There are 352 ha of high land, 953 ha of impoundments and 1,396 ha of salt and brackish water marsh on the island. The maritime forest consists of live oak, loblolly pine, southern magnolia, southern red cedar, hickory, wax myrtle, cabbage and sabal palmetto and hollies. South Island incorporates the best of two worlds: one similar to North Island's wilderness and the other like Cat Island's manipulated habitats.

Cat Island was mainland up until the late 1920s, when the Intracoastal Waterway or Estherville Minim Creek Canal was completed. By isolating the entire property, the canal created an island-complex which afforded further protection to the wildlife living within its boundaries. Currently including over 6,650 ha, South and Cat Islands are essentially parts of the same land form.

At the same time waterfowl management was expanded, a program of selective timber thinning, prescribed burning and wildlife opening maintenance enhanced the deer and turkey populations. The present 43 wildlife openings and park-like appearance of the pine forest provide ample habitat for deer and turkey.

Gradually developed from marshland and natural ponds, South Island's 12 major waterfowl impoundments successfully attract thousands of ducks each year. Designated by Yawkey as an "inviolate waterfowl area," the 953 ha of impoundments provide habitat for such species as mallards, shovellers, pintail, gadwall, widgeon, blue and green-winged teal, black, ring-necked, canvasback, ruddy duck and coot. In recent winters, whistling swans, Canada and snow geese have also visited the impoundments in representative numbers. Past records show that the waterfowl habitat on South Island has attracted duck and geese populations peaking at over 100,000 in December.

Shallow-water birds like plovers, egrets, willets, herons, and gulls are drawn to South Island by the regular rotation of water levels in the impoundments. Avocets, usually western migratory birds, can be seen now during every month of the year, sometimes congregating in hundreds. Black-necked stilts, wood storks, sandhill cranes, glossy ibises and even a white pelican have wintered at South Island.

In addition to protecting game species and shorebirds, the Center is a haven for non-game and endangered species. An unusual number of raptorial birds, for instance, frequent the Yawkey Center property for migratory resting, nesting, or feeding. These include several varieties of hawks, as well as osprey, peregrine falcon and golden and bald eagles.

A number of active nest cavities for the red-cockaded woodpecker are also known to exist throughout the forest of Cat Island. Also recognized as an endangered species, these highly selective woodpeckers require the specialized habitat that only old-growth pine can provide.

In addition to providing for small mammals like bobcat, raccoon, fox squirrel and otter, the island protects the alligator and the loggerhead sea turtle. The Yawkey Center's alligator population is unique in that it has been protected over a long period of time, providing an ideal control group for research in alligator reproductive behavior studies.

To ensure that his conservation practices would be advanced beyond his lifetime, Yawkey bequeathed the property to the Wildlife Department to be used for all time for wildlife management, education and research. A ten-million-dollar trust fund was also left to be administered by the Yawkey Foundation Trustees, who may grant income from the fund for the property's total operation. Yawkey's will stipulates that the islands will be used now essentially as they were under Yawkey's stewardship. North Island is designated a wilderness where no activities detrimental to its primitive character are permitted. South Island is held for the protection of waterfowl in which no duck hunting is permitted. The remainder of the property is held as a wildlife management area for migratory birds, native game and nongame.

Academic institutions, government agencies and natural resource-oriented organizations and/or individuals are encouraged to submit proposals for projects they wish to conduct at The Yawkey Center.

The Santee Coastal Reserve and the Washo Reserve

History

The Santee Coastal Reserve is approximately 8,900 ha and is located at the mouth of the Santee River. Contained within it is the Washo Reserve, a 421-ha freshwater cypress swamp. In 1974, the Santee Gun Club donated the property to The Nature Conservancy. Through the Heritage Trust Program, the property was acquired by the State of South Carolina, but The Nature Conservancy retained the portion containing the Washo Reserve.

In the 18th century, this property became part of the network of plantations which prospered on cotton, rice and indigo in the Santee Delta. Joseph Blake created a freshwater reserve supply in the late 1700s by damming a small creek running through this portion of the Santee swamp to control water needed for the rice fields. This became known as Blake's Reserve or Washo Reserve. Members of the Santee Gun Club, which used the area as a hunting preserve, showed a strong concern for the wading bird rookery located within the Washo. The area was patrolled and protected from poachers during the days of the active plume trade (S.C. Nature Conservancy 1985). In the early 1900s, the reserve contained probably the largest wading bird rookery on the east coast. The rookery is still active today. In addition, Washo Reserve has over 40 active osprey nests, wood ducks and numerous cavity nesting species of birds.

Ecological Setting

The Santee Coastal Reserve consists of two barrier islands, Cedar and Murphy, plus additional lands west of the Intracoastal Waterway. Cedar Island, situated between the North and South Santee Rivers, has a sandy beachfront 4.8 km long and includes both high ground and marsh. There are 113 ha of high land, 1,093 ha of impoundments and 433 ha of unmodified salt marsh (Warner and Strouss 1976). Cedar Island was used by rice planters in the early 1800s as a retreat from the diseases of the swamp that reportedly infested the nearby plantations (Doar 1908).

A broad expanse of impounded marsh separates Murphy Island from the mainland. There is a sandy beachfront 6.6 km long, 279 ha of high land and 2,971 ha of marsh, including 2,226 ha of impoundments (Warner and Strouss 1976). The northern portion facing the South Santee River has undergone net erosion as the main channel migrates southward, a local loss of some 650 m (Stapor and Mauali 1978).

The part of the property that is on the mainland has several Carolina bays, elliptical depressions of unknown origin.

Current Land Uses

The State will continue to manage the Santee Coastal Reserve for waterfowl habitat, but will permit limited recreation in the area for non-consumptive uses and deer hunting. The Washo Reserve is owned by The Nature Conservancy and managed under a lease agreement with the S.C. Wildlife and Marine Resources Department. The area has been established as a wildlife sanctuary to be used solely for scientific, educational and aesthetic enjoyment. The Washo Reserve is also a core area in the biosphere reserve.

The Cape Romain National Wildlife Refuge

History

This area has long been considered an earlier Holocene delta of the Santee River. The Seewee Indians inhabited this area before the English settlers. Bull Island was used by the settlers to resupply their stores of lumber and other materials, and Bulls Bay and the adjacent creeks were hideouts for pirates. Two lighthouses at the easternmost point of land on that part of the coast were built in 1827 and in 1857. They are no longer operational, but still serve as day markers. The Cape Romain National Wildlife Refuge was established in 1932 as a migratory bird refuge. Bulls Island was added to the refuge in 1936 by a purchase from Mr. Gayer Dominick.

Ecological Setting

The Cape Romain region, now undergoing net erosion, has extensive coastal marshes and a true embayment, Bulls Bay. The refuge encompasses 13,857 ha of marsh, four major barrier islands, tidal creeks and bays.

Cape Island is a cuspate foreland. Sediments eroded from the apex of the cape move away in two directions, forming recurved spits to the north and to the west. All other localities along the front beach of Cape Island show net erosion. A broad expanse of salt marsh separates the island from the mainland. The island has a sandy beachfront along its entire length of 8.5 km. The major components of the shrub community are wax myrtle, southern red cedar and hollies. The only large trees on the island are loblolly pines. The area is also recognized as one of the major nesting beaches for the threatened loggerhead sea turtle. The refuge staff monitors loggerhead turtle nesting and moves approximately 500 nests per year into protective, self-releasing hatcheries. The island is undeveloped and has restricted public access (Warner and Strouss 1976).

Lighthouse Island is a low marsh island. There are 382 ha of land, of which 15 ha are high land and 367 ha are marsh (Warner and Strouss 1976). The island has a sandy beachfront that is 3.2 km long. It is similar in description to Cape Island.

Raccoon Key is also a low marsh island. There are 67 ha of land, of which 10 ha are high land and 57 ha are salt marsh (Warner and Strouss 1976). The island has a shelly beachfront that is 8.7 km long. The transgressive shoreline consists of eroding marsh mud, a low sand and shell berm and washover terraces.

Bulls Bay is a large, shallow embayment. It is a major shore bird wintering area and sea bird nesting area, containing some of the largest rookeries on the southeast coast. It has a history of birding since the days of Audubon. Bulls Bay also contributes to the local economy with a significant shellfish industry.

Bull Island is the largest of four islands which make up the Cape Romain National Wildlife Refuge. A maze of tidal creeks and small marsh islands separates the island from the mainland. There are some 1,821 ha on Bull Island, of which 801 ha are high land and 1,020 ha are salt marsh. The island has a sandy beachfront along its entire length of 10.9 km. The impounded areas on the island are managed for waterfowl and provide excellent brackish water habitat for migrating waterfowl and shore birds.

Current Land Uses

On Bull Island, managed archery hunts to control the deer population are allowed in the fall. Nature trails crisscross the island and the area provides valuable nesting habitat for several species of birds as well as loggerhead turtles. The island is undeveloped, but some 15,000 to 20,000 people tour the island each year (Warner and Strouss 1976). Bull Island is currently one of the sites for the red wolf recovery efforts. It is not a reintroduction site, but is being used as a breeding facility. An adjacent area of 12,000 ha of open water is closed by Presidental Proclamation to the taking of migratory birds, and a 11,300-ha area is within the National Wilderness Preservation System (U.S. Fish and Wildlife Service 1987).

Capers Island

History

The exact history of Capers Island has been lost, but it was one of several sea islands given as grants by the King of England to the colonists. The island was under cultivation in the eighteenth century when sea island cotton and indigo were the major crops. The island was operated as a farming entity until the boll weevil killed the sea island cotton industry, prior to World War I. Capers Island was purchased by the State of South Carolina in 1974 as a natural area and wildlife refuge.

Ecological Setting

Capers Island is the southernmost barrier island in the biosphere reserve and has a sandy beachfront that is 5.3 km long. Capers Island has 344 ha of high ground, 441 ha of unmodified salt marsh, 20 ha of tidal creeks and 45 ha of fresh and brackish water impoundments (S.C. Wildlife and Marine Resources Department 1975). Capers Island is a Holocene barrier island with a maritime forest community. It is currently eroding along most of its front beach. Erosion is particularly severe at the southeast end of the island, where the forest cover has been undermined and a low bluff exists. There is evidence that erosion has been occurring since 1875.

Current Land Uses

The S. C. Wildlife and Marine Resources Department is directly responsible for the management of this island. Current usage and management are directed toward maintaining a natural habitat for marine life, waterfowl, shorebirds and other native vertebrates while allowing visitors. Camping is by permit only and the number issued is controlled. Nature trails are maintained within the maritime forest. To perpetuate the natural character of the island, Capers Island has been designated as a South Carolina Heritage Preserve.

The Santee Delta Ecosystem

Aburwi (1972) and Woollen (1976) indicate that the Santee Delta has been in its present position since at least 4,500 years ago. Colonial and 19th century rice cultivation resulted in the impounding of extensive tracts of marsh and hardwood swamps in the Santee Delta. With the demise of rice, many of the impoundments became waterfowl hunting areas or open tidal marsh.

Santee-Cooper Diversion and Rediversion

The Santee-Cooper Diversion and Rediversion projects represent a physical alteration of the coastal region second in magnitude only to the colonial and 19th century impoundment of marshes for rice cultivation. The Santee-Cooper Diversion Project was first proposed in 1915 as a means of generating hydroelectric power (U.S. Army Corps of Engineers 1975). Santee River discharge was to be diverted into the Cooper River so that the topographic scarp at Pinopolis, Berkeley County, South Carolina, could be utilized to provide hydraulic head. Dams were constructed to impound each of these rivers, insuring a constant water flow. The South Carolina Public Service Authority began construction in 1938 and electric generation began in February 1942 (U.S. Army Corps of Engineers 1966a).

Wilson Dam formed Lake Marion and Pinopolis Dam formed Lake Moultrie. These two lakes are connected by a 12-km-long diversion canal through which passed, on the average, 88% of the Santee River's annual discharge from the Santee into the Cooper River (Kjerfve 1976). When the project was under consideration, ". . . it was believed that there would be many incidental benefits, including reduction of shoaling of the navigation channels in the Charleston Harbor, improvement of water quality in Charleston Harbor through flushing resulting from the greatly increased freshwater discharge, and of course desalinization of the upper and middle reaches of the Cooper" (U.S. Army Corps of Enginers 1966a). Of these three mentioned incidental benefits, the last two occurred as predicted. However, increased freshwater discharge exacerbated rather than reduced shoaling in Charleston Harbor. Maintenance dredging of navigaton channels and auxiliary facilities increased by a hundred-fold. The U.S. Army Corps of Engineers, Charleston District, began investigating this ". . . appalling increase in shoaling . . ." in the early 1950s. By the middle 1960s they were able to conclude ". . . beyond any reasonable doubt that the increased freshwater flows into the harbor and the change in the regime to the harbor from the characteristics of a well-mixed estuary to those of a partly mixed estuary, as a result of the diversion of large freshwater flows from the Santee into the

Cooper, are the principal causes of the present heavy shoaling of the navigation channels" (U.S. Army Corps of Engineers 1966a).

The lower Santee River and its delta experienced a significant increase in salinity from a pre-diversion level of 1°/oo or less at the mouths of the North and South Santee Rivers (Kjerfve 1976) to a post-diversion level of 20°-24°/oo at these mouths (Mathews et al. 1980). Commercial oyster and hard clam beds developed in the North and South Santee Rivers as a result of the diversion and resulting salinity change. Along with the pronounced overall increase, the salinity range remained high. Sediment deposition and erosion also resulted from diversion. The mouth of the North Santee River became filled with marine sands moving into the estuary under the changed tidal circulation pattern (Mullin 1973). Stephens et al. (1976) have suggested that coastal erosion of the Santee Delta (South, Cedar, and Murphy Islands) likewise accelerated after diversion.

In order to alleviate the Charleston Harbor shoaling problem, the U. S. Army Corps of Engineers (1966b) considered ten plans of improvement. The plan ultimately selected was to divert water from Lake Moultrie through a 18.5-km-long canal to the Santee River. The Santee Cooper Rediversion Project was authorized in 1968. Construction began in 1977 and was completed in 1985. The increased freshwater discharge has eliminated the oyster and clam beds in the North and South Santee Rivers, but not enough time has passed to determine trends in the erosional cycles of the nearby barrier islands. Monitoring changes in Charleston Harbor and in the Santee Delta is being conducted by the Marine Resouces Research Institute of the S.C. Wildlife and Marine Resources Department.

Regional Issues

Regional resource uses and management issues involved with this reserve are: dredging and filling, rediversion of the Santee River, management and use of impounded marsh, and beach stabilization projects. A major cooperative effort was the publication in 1980 of The Ecological Characterization of the Sea Island Coastal Region of South Carolina and Georoia by the U.S. Fish and Wildlife Service. The study results have been published in five volumes describing (1) physical features, (2) socioeconomic features, (3) biological features, (4) directory of information sources and (5) an atlas. Research and monitoring are continuing within the Santee Delta-Cape Romain Unit of the biosphere reserve under such programs as Sea Grant, Endangered Species Grant-in-Aid and the National Science Foundation. These five volumes provide an excellent baseline for future studies.

Recent MAB Activities

Soon after the designation was official, efforts began to implement parts of the Action Plan and to develop biosphere reserve functions. Biannual workshops were held in South Carolina and Georgia to familiarize managers with the biosphere reserve concept and ongoing research and management within each unit. Unit and reserve coordinators were appointed and are currently carrying out necessary tasks. These include distributing the new biosphere reserve brochures, erecting signs with the MAB logo and designation, producing a directory of unit participants and interested parties, and discussing tentative plans for regional and local symposia.

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VIRGIN ISLANDS BIOSPHERE RESERVE: PROGRESS REPORT

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ABSTRACT. The Virgin Islands Biosphere Reserve (VIBR), St. John, U.S. Virgin Islands, has made progress in fulfilling many of the objectives of the UNESCO Action Plan. Members of the Virgin Islands Resource Management Cooperative have completed 29 projects on fisheries, marine ecosystems, the island's forests, and on implementation of the biosphere reserve concept. The Virgin Islands Biosphere Reserve Center is a center of research activity and, in the future, will become more of a center for training and education. More effort is required to integrate local people into the management of the biosphere reserve. The VIBR requires direction for the future and still lacks a management plan. The recently formed Friends of Virgin Islands National Park could play an important role in facilitating the involvement of the local community, as well as building a cooperative MAB program on St. John. A biosphere reserve coordinator is needed.

KEY WORDS: Biosphere reserve, U.S. Virgin Islands, tropical forests, Caribbean marine ecosystems.

Virgin Islands National Park (VINP), St. John, U.S. Virgin Islands, was designated a biosphere reserve in 1976. It is the only biosphere reserve in the Lesser Antilles. The Virgin Islands Biosphere Reserve has accomplished a great deal but now faces many challenges. Here we examine the VIBR's progress in relation to the UNESCO Action Plan. The plan lists several objectives and a minimum set of activities for implementation in each biosphere reserve, including: (1) establishment of research facilities and a research program; (2) establishment of monitoring procedures; (3) compilation of baseline inventories; (4) preparation of a history of research; (5) establishment of a training/education program; and (6) preparation of a management plan specifying steps to be taken in developing biosphere reserve functions.

Research

Objective 4 of the Action Plan is "to promote coordinated research projects on conservation, science, and ecology within biosphere reserves."

Only a few years ago, VINP managers lacked basic data on natural resources and had few management guidelines. Now we have a more solid baseline and an overall framework within which decisions can be made. Between 1983 and 1988, the National Park Service provided over 1/2 million dollars for a series of research projects carried out by the Virgin Islands Resource Management Cooperative (VIRMC). VIRMC, a cooperative venture in research and resource management which began in 1982, consists of the National Park Service and 15 other members, including territorial and federal government agencies and private research and educational institutions based in the U.S. Virgin Islands, the British Virgin Islands, and Puerto Rico. The Cooperative brings together local expertise to work toward the solution of shared resource management problems.

VIRMC research has emphasized baseline studies, monitoring, and synthesis of information. VIRMC members completed 29 projects from 1983-1988. All project reports have been printed and distributed. Many of the projects were part of an interdisciplinary approach to watershed management, with studies of local fisheries, coral reefs, seagrass beds, and effects of sedimentation on marine communities. A synthesis of research and resource management information, with a history of research pertinent to VIBR, was completed in the Fall of 1988.

Restoration of Degraded Ecosystems

Priority research topics in biosphere reserves include (1) succession and regeneration and (2) restoration of degraded ecosystems. Most of the island of St. John was cleared for the production of sugar cane, cotton and other crops in the late 1700s and 1800s. The Virgin Islands National Park on St. John is the only protected area in the Caribbean where forests have been able to recover after extensive clearing. Studies of succession are already underway by the University of the Virgin Islands, the Institute of Tropical Forestry, the New York Botanical Garden and the University of Wisconsin's Institute for Environmental Studies. Scientists from the University of Wisconsin have received MAB funding for a two-year study on restoration of St. John's dry forest. The Smithsonian Institution is exploring the possibility of working on St. John as well. Much of the work will focus on long-term monitoring and preservation of native species and the development of methods for reintroduction of rare and endangered species. The Smithsonian's interest arises out of its joint program with MAB to address the loss of biological diversity in developing tropical countries.

The seagrass beds in Francis and Maho Bays on the north side of St. John also represent degraded ecosystems. These bays support a relatively large population of the threatened green turtle and the endangered hawksbill turtle. Anchors (and the chains attached to them) from the increasing number of boats visiting these bays are a primary stress. Small portions of both bays have been closed to anchoring, and a recommendation to prohibit anchoring in most areas of these bays and to establish a mooring system is now under consideration.

Recent studies have shown severe localized damage to coral reefs from anchors and from boats striking and grounding on them. Cruise ships from 200 to 500 feet long are visiting the park more frequently, and their anchors are causing especially serious destruction. A few of these ships are no longer permitted to anchor in park waters. Marker buoys have been established off two reefs as a warning to boaters, but more action must be taken to reduce the damage.

Baseline Inventories

VIRMC projects in 1984 focused on gathering baseline information on local fisheries and on bays around St. John and the British Virgin Islands. Maps showing the major coral reef zones, seagrass beds and other benthic (bottom) communities were produced using aerial photographs and field surveys. Collections of common marine organisms were assembled.

The National Park Service also funded a study of the vegetation of St. John, which resulted in a vegetation map for the island and a listing of 800 species of plants, including rare, endangered, and new species. The New York Botanical Garden is producing a comprehensive, illustrated field guide to the flora of St. John.

Virgin Islands Biosphere Reserve Center

The National Park Service has made a strong commitment to the biosphere reserve program through the construction of the Virgin Islands Biosphere Reserve Center. The Center's four buildings include housing for visiting scientists and students, a small laboratory, offices for the park's Research and Resource Management Division, a collection area, and a conference room. The herbarium and other collections referred to above are housed at the facility. The conference room is frequently used for presentations on research and resource management in the park.

Monitoring

Objective 5 of the Action Plan is "to develop monitoring activities in biosphere reserves in order to provide a basis for scientific research and management activities and contribute to the understanding of environmental changes."

Long-term monitoring is considered of highest priority in VINP. Long-term plots have been established in four watersheds on St. John, and standard forestry measurements have been recorded. The Institute of Tropical Forestry in Puerto Rico and the New York Botanical Garden are committed to maintaining these sites. Additional long-term plots will be established in 1989 in dry forest areas by scientists from the University of Wisconsin.

Long-term monitoring transects have also been established on coral reefs in four bays around the island. The IUCN's world conservation strategy identifies reefs as one of the essential life-support systems for human survival and sustainable development. The National Park Service has provided over $450,000 for a 3-5 year project to establish long-term assessment programs for coral reefs under NPS jurisdiction, including those in VIBR, as a basis for more effective management.

VIRMC has already initiated monitoring of populations of lobsters, conchs, whelks and reeffish, and there are plans to study the status of some of the seagrass beds around the island. A system of water quality monitoring stations was established in 1988.

Final reports for several VIRMC projects outline simple monitoring methods which are appropriate in areas where technical expertise and financial resources are limited. Techniques have been described for marine and terrestrial systems.

Information

Objective 9 of the Action Plan is to "use fully the potential of the network to generate and spread knowledge about the conservation and management of the biosphere and to promote the biosphere reserve concept through information and demonstration."

In 1983, formal dedication of the VIBR took place along with a workshop on "Biosphere Reserves and Other Protected Areas for Sustainable Development of Small Caribbean Islands." Proceedings of this workshop are available. In March 1987, VIRMC members, St. John residents, and Caribbean resource managers met to dedicate the new Virgin Islands Biosphere Reserve Center.

A videotape on VIBR has been prepared for distribution throughout the Caribbean and elsewhere. One VIRMC project made recommendations on the selection of a database management system for VIBR. A document synthesizing research pertinent to resource management in the Virgin Islands is now complete. This report includes a comprehensive bibliography. The National Park Service has printed an attractive brochure on the Virgin Islands Biosphere Reserve.

Challenges

The Virgin Islands Biosphere Reserve program now faces many challenges. It will prove itself only if it accomplishes the following:

1. A successful balancing of the increasing pressures from the island's rapid development and tourism on the natural resources with conservation of these resources;

2. Demonstration of direct benefits to island residents;

3. Integration of local people into management of the biosphere reserve;

4. Dissemination of information from VIRMC research projects and from effective resource management actions to other islands/countries with similar ecological problems;

5. Establishment of the Virgin Islands Biosphere Reserve Center as an education/training center for the Caribbean region; and

6. Conservation of the VIBR as a benchmark against which the status of surrounding unprotected areas can be evaluated.

Balancing Development and Conservation

A recent VIRMC study of the trends and consequences of recreational uses of Virgin Islands National Park indicated the following:

1. Recreational visits to the park have risen from less than 100,000 people prior to 1967 to over 750,000 in 1986;

2. Annual visitation to Trunk Bay beach, the most heavily used beach in the park, has risen from under 20,000 people in 1966 to almost 170,000 in 1986; and

3. The average number of boats per day in park waters ranged from less than 10 in 1966 to 80 in 1986.

One consequence has been the degradation of the park's coral reefs and seagrass beds, particularly along the north shore of the island which receives the heaviest use. Anchor damage and damage from boats striking or grounding on reefs is severe in some locations. Seagrass beds in popular bays have deteriorated.

In addition to the direct impacts of recreational uses, the effects of accelerating development of St. John's watersheds are being evaluated. The potential damage to nearshore marine ecosystems from land-based sedimentation associated with clearing on steep hillsides is a major concern.

The challenge is whether the Biosphere Reserve program can function to achieve a successful balance between increased use and development of the coastline and inland watersheds, and the protection of the resources which have already suffered some degradation.

Demonstration of Benefits

Biosphere reserves are intended to provide "economic and social benefits for local people," with these benefits resulting from "the protection of natural and managed ecosystems" (UNESCO Action Plan). However, for the biosphere reserve program to gain acceptance, more specific benefits need to be demonstrated.

One example might be as follows: Only after input from fishermen and others, close the southern park waters to all fishing because of evidence that the fisheries, even within the protected park waters, have seriously declined. Allow recovery of fish populations to the level where fishing can once again be sustained. Increased harvests of lobsters, conchs, and reeffish would be a specific benefit based on a resource management action arising out of local participation in management of the biosphere reserve.

Dissemination of Information

VIRMC reports from all projects are now available and copies have been sent to individuals and institutions in the region. The park's Research Biologist has given many seminars on the biosphere reserve program. The park's research and resource management staff is receiving more and more inquiries about marine resource management issues and is assisting people from other Caribbean islands.

Local Participation

In conjunction with VIRMC projects, meetings have been held with local fishermen and others to discuss conflicts arising over use of the island's marine resources and the biosphere reserve program in general. Some Virgin Islanders have been trained in research and resource management while assisting on forestry and coral reef projects. A VIRMC report on the "Conceptual Framework for Management of the Virgin Islands Biosphere Reserve" stresses the importance of local participation in developing a management plan for this biosphere reserve. A group of local residents formed the Friends of Virgin Islands National Park in 1988. One of their objectives is to encourage better communication and interaction between the park and the local community within the transition area of the biosphere reserve. However, much more effort needs to be made to incorporate local people into the biosphere reserve program.

Education and Training

Biosphere reserves should play a role in the education and training of resource managers and local residents. The completion of the Virgin Islands Biosphere Reserve Center in late 1986 has opened up many possibilities. The Center has already been used for teachers' workshops, meetings of park interpreters with the Virgin Islands Taxi Association, and scientific presentations. It will be the site of a coral reef rehabilitation workshop in December. A series of seminars on research and resource management and on the biosphere reserve program was presented. The NPS Office of International Affairs has agreed to provide funding for individuals from the Caribbean to come to St. John for training in research, resource management, and overall park operations.

Cooperation in solving common resource management problems and sharing of expertise should be emphasized. The British Virgin Islands National Parks Trust and the Ministry of Natural Resources are cooperating with the VIBR in addressing problems associated with tourism and coastal development. For example, scientists from the local USVI Division of Fish and Wildlife and the VINP went to Tortola to assist in developing a monitoring program for a bay scheduled for dredging and hotel development. The British Virgin Islands has provided VINP with information on mooring systems and regulation of cruise ships.

Strengthening Links Between Research and Management

The biosphere reserve should conserve the representative terrestrial and marine ecosystems of St. John within the context of sustainable human uses. It should include a strictly protected area for comparison with unprotected areas in the Virgin Islands and elsewhere in the Caribbean. Research should be closely linked to management.

Research in the biosphere reserve has already provided support for management actions. For example, VIRMC projects have shown degradation of reef and seagrass systems in the park and depletion of the reeffish and shellfish populations. As a result, marker buoys have been installed to warn boaters of the location of especially vulnerable reefs, and the amount of damage (e.g., broken corals) has been reduced substantially. Also, "no anchoring" zones have been established in a few seagrass areas to allow recovery. Park managers are currently reviewing a draft Shoreline Management Plan and intend to take further action to reduce damage to park resources.

Virgin Islands Biosphere Reserve: A Model?

Perhaps the final challenge faced by this biosphere reserve is whether it can serve as a model for other areas. With its proximity to the British Virgin Islands, its location in a region of small developing countries, and the resultant opportunities for cooperation in solving shared resource management problems, the Virgin Islands Biosphere Reserve may be in a better position to realize and implement biosphere reserve functions than many other U.S. biosphere reserves. The potential role of the VIBR in the Lesser Antilles is being considered in an ongoing review sponsored by UNESCO and UNEP to assess possibilities for developing a coordinated network of biosphere reserves.

Virgin Islands Biosphere Reserve: What Next?

The National Park Service has made a strong commitment to the biosphere reserve program, particularly in its support of research. However, in Virgin Islands National Park, there is no one with authority or responsibility to work fulltime on the program. The Friends of Virgin Islands National Park could play an important role in developing a cooperative MAB program. A full-time biosphere reserve coordinator working on behalf of all the interests involved is needed. In the near term, there is a need to develop a biosphere reserve plan with full participation of resource users and relevant Federal and territorial resource management agencies. The functional zones of the biosphere reserve need to be delineated. Particular attention should be given to establishing the Lameshur and Reef Bay watersheds as core areas. For the VIBR to be fully successful and effective, there must be broad recognition of its importance in maintaining the biological diversity of the region. Further direction and guidance from the Man and the Biosphere Program is needed.

COASTAL AND MARINE BIOSPHERE RESERVE NOMINATIONS IN THE ACADIAN BOREAL REGION: RESULTS OF A COOPERATIVE EFFORT BETWEEN THE U.S. AND CANADA

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ABSTRACT. Achievements and progress made by the U.S. and Canadian Biosphere Reserve selection panel are reported. The panel has focused on three areas within the Acadian Boreal Region as potential biosphere reserve nominations. The first of these is a coastal/riverine area at the mouth of the Saguenay River in Canada. The remaining two are potential transboundary reserves, one at the mouth of the Bay of Fundy and the other extending from Cape Cod, Massachusetts to northeastern Nova Scotia. Some of the aspects of designing and implementing such largely marine and therefore unique biosphere reserves are discussed.

KEY WORDS: Bay of Fundy, Gulf of Maine, marine biosphere reserves, transborder reserves, zonation, fisheries, marine ecosystems.

In September of 1986, the U.S. and Canadian National Committees for Man and the Biosphere convened a panel of Canadian and American resource managers, policy makers, and scientists to recommend coastal and marine areas within the Acadian Boreal biogeographic region as potential biosphere reserves. This panel's ongoing task has been to identify areas of ecological representativeness, ecological importance, and feasibility in a very diverse and complex province.

The Acadian Boreal Region of North America (Figure 1) encompasses the coastal area from Cape Cod, Massachusetts northwards to Newfoundland, Canada (Udvardy 1975). It is an area characterized by evergreen forests and rocky shorelines in the north, beaches and scrub vegetation in the south, and highly productive, tidally mixed coastal waters throughout its range. In this region the sea is a dominant force affecting both the ecology of the area and the socioeconomic activities of its people.

The Biosphere Reserve Project is one of many activities undertaken by UNESCO's Man and the Biosphere Program (MAB). Its objectives are to identify and designate areas of special ecological and sociological interest worldwide. Biosphere reserves differ from other more traditional protected areas in many ways: (1) they encompass larger areas that comprise major portions of a region's ecosystems; (2) they include sub-areas with differing degrees of human use and legal protection; (3) they focus on areas of special interest, such as those of high biological diversity and endemism, or areas that have been modified or are suitable for experimental manipulation; and (4) they stress research and monitoring activities and public education as essential activities. Therefore, biosphere reserves can be said to fulfill not only a conservation role, but logistic and development roles as well, integrating the three types of activities in a comprehensive management scheme (Batisse 1986). Biosphere reserves also provide new opportunities for local, regional and international cooperation, and in some cases such as in the Acadian Boreal region, unique possibilities for transborder cooperation in research, conservation and management activities.

MAB directs the selection and ultimately the design of biosphere reserve nominations by requiring that specific criteria be met (UNESCO, 1987). These criteria stipulate that nominations include: "core" areas that are strictly protected and relatively pristine, "buffer" areas where resource use is controlled but where exploitation occurs in varying degrees, and "transition" areas or areas of cooperation that can include special areas of ecological interest or scientific cooperation but where legal protection is often tenuous. In order to meet the objectives of the program, core areas and buffer zones of biosphere reserves must be assured of having long-term institutional or regulatory protection.

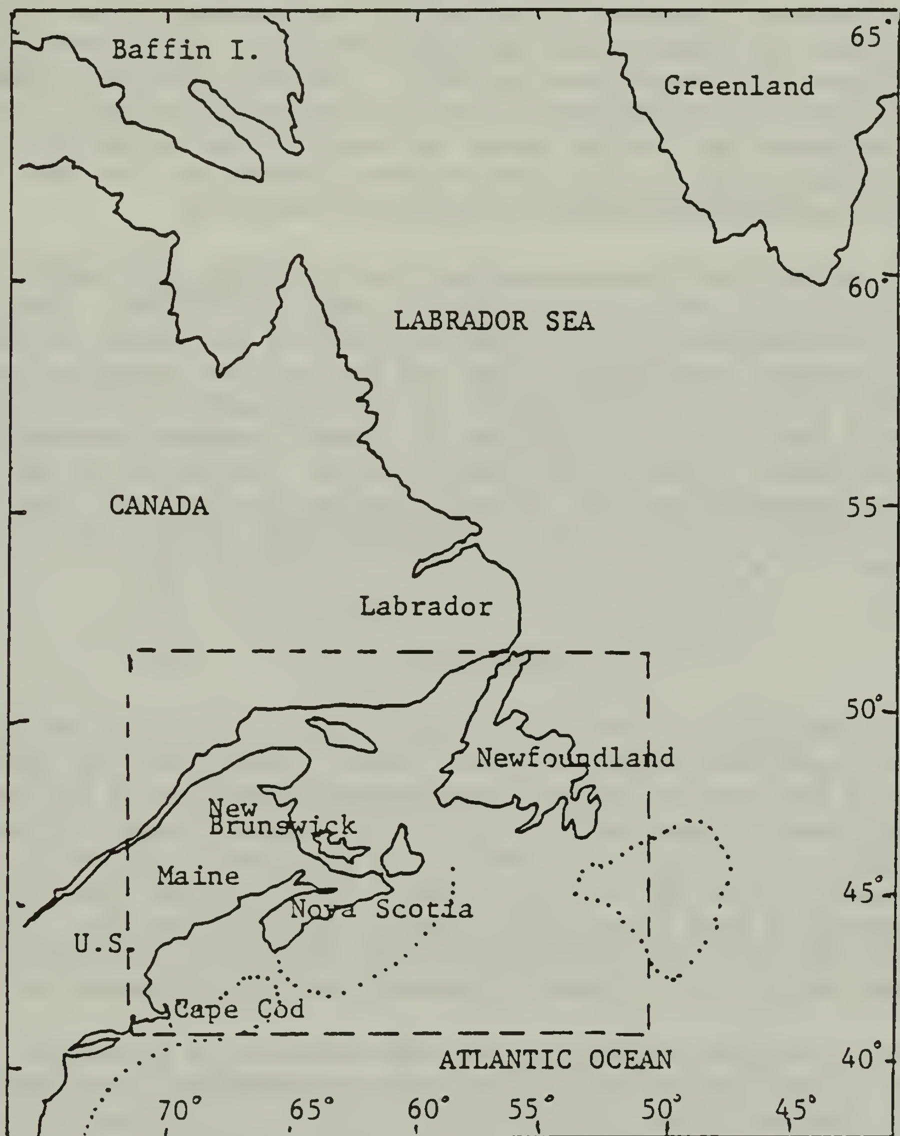

Figure 1. Approximate limits of the Acadia/Boreal biogeographic province.

Due to the nature of coastal and marine area legislation in both Canada and the United States, these selection criteria are difficult to meet in a region that extends well beyond the borders of state and provincial jurisdiction and for which the limits of national jurisdictions are still being defined. Although both the United States and Canada have zones of limited protection extending to 200 miles beyond the coast, the level of legislative control afforded by the U.S. Exclusive Economic Zone (EEZ) or Canadian Fisheries Conservation Zone (FCZ) is probably not sufficient to allow the delineation of core areas at sea. For this reason, the Acadian Boreal Panel has in some cases considered recommending areas which are largely marine but which are "anchored" by strictly protected coastal parks.

The Acadian Boreal Selection Panel has focused on three potential biosphere reserve nominations that consist of areas representative of the region. The first typifies the northern gulf systems and is located at the mouth of the Saguenay River in Canada. The second area highlights the tidally mixed and highly productive region below the mouth of the Bay of Fundy and the insular areas within it. The third potential reserve features more oceanic processes and encompasses a vast area extending northeast from Cape Cod to include the Stellwagen and Georges Banks and much of the Scotian Shelf. The three areas, although characteristic of the Acadian Boreal Region on the large scale, have differing ecological qualities and distinctive patterns of human use.

All three of the potential nominations could be accepted as biosphere reserves by UNESCO; alternatively, as few as one nomination might be accepted. Should the latter scenario occur, the delineation of that prospective reserve will change in the process of selection. Each, however, has its own merits and has, we feel, important potential as a coastal and marine protected area. Two of the three prospective recommended areas span the borders of the U.S. and Canada, and all contain elements managed by different entities. The biosphere reserves thus would require developing a mechanism for cooperation in management and education activities. International and interagency cooperation is especially essential in the two transboundary reserves, and these are the focus of this paper.

Fundy/Maine

A Fundy/Maine Biosphere Reserve could span the entire mouth of the Bay of Fundy from Campobello Island, New Brunswick to Brier Island, Nova Scotia, and south to include Grand Manan Island, Machias Seal Island (a disputed area), a portion of Jeffreys Bank, and Mt. Desert Island, Maine (Acadia National Park). This roughly triangular area (see Figure 2) includes regions of significant tidal mixing and high species diversity, and includes several coastal parks of both the U.S. and Canada. The terrestrial areas that would fall within the boundaries of such a reserve are characteristically Acadian, with coniferous forests, peat bogs, mud flats, and rocky high intensity shorelines. The outer limits of this prospective reserve would define an area of approximately 700 square nautical miles.

The Fundy/Maine proposal would meet the many objectives of a biosphere reserve. Its core areas might include pristine or minimally disturbed portions of well-managed parks, such as Acadia National Park, Petit Manan Reserve, the bilaterally-administered Roosevelt Campobello International Park, and the Brier Island Refuge. In addition, the reserve could incorporate many non-governmental protected areas administered by private individuals, citizens groups, and conservation organizations. The area has a long

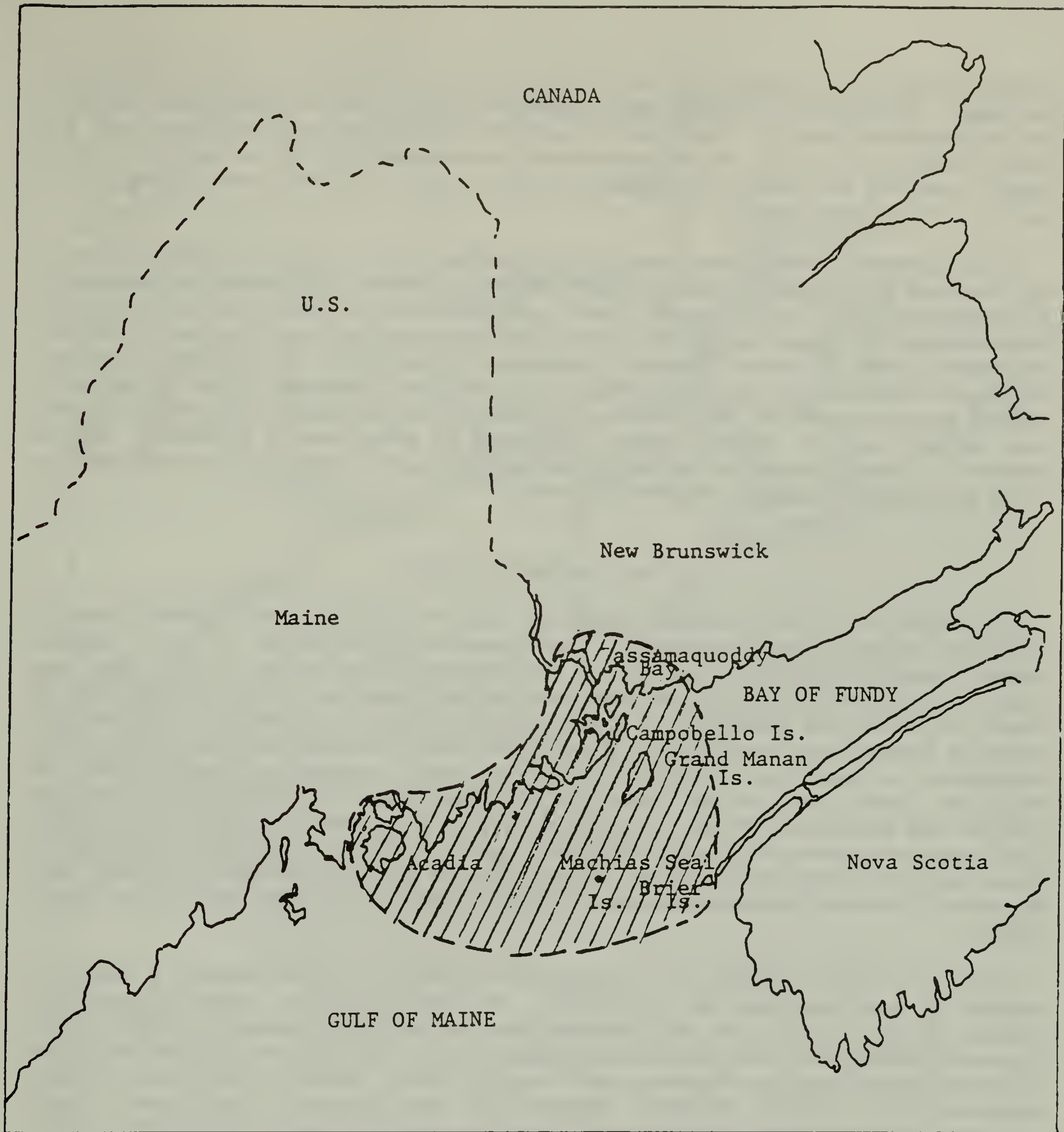

Figure 2. Outer limits of the proposed Fundy/Maine Biosphere Reserve.

history of scientific research and may be one of the best-studied coastal ecosystems in the world. The potential for bilateral cooperation is great and would be a key factor in the design of the reserve. Furthermore, although highly protected core areas exist, the buffer zones of compatible use and development surrounding the core areas, as well as the largely estuarine and open ocean transition areas, reflect a strong human dependency on the local marine resources.

A word should be interjected here on the central role of man in biosphere reserves. The Man and the Biosphere Program has attempted to stress that controlled exploitation at sustainable levels is ecologically sound, and that man can live in harmony with the ecosystem rather than as an adversary to it. This represents perhaps the most significant departure of the Biosphere Reserve philosophy as compared to traditional park and wilderness management. In the potential Acadian Boreal Reserves, areas of particular interest would include not only pristine fragments of the ecosystem with which man has only minimal contact, but also highly used areas on which man is dependent. This is especially true with regard to the highly productive coastal waters within the boundaries of the proposed Fundy/Maine Biosphere Reserve.

Cape and Banks Reserve

A prospective Cape and Banks Biosphere Reserve similarly could include areas of traditional human use and dependency. This reserve might encompass an arc of land and water extending from Cape Cod Bay to the northern limits of the Scotian Shelf (see Figure 3). Included in this potential reserve would be Stellwagen Bank, an inshore area of great importance to cetaceans as a feeding site; Cape Cod National Seashore and Monomoy Refuge, notable not only as a significant protected beach system but also for its importance in supporting seabird colonies; the highly productive fisheries areas on Nantucket Shoals and Georges Bank; the hydrographically important Oceanographers Canyon; and the coastal Woods Property located on the eastern coast of Nova Scotia. This biosphere reserve would potentially encompass a total area of approximately 180,000 square nautical miles and would link the communities of Cape Cod and the islands with the coastal communities of eastern Nova Scotia in the same ecosystem and resource-based region.

There are both scientific and sociological reasons for recommending a biosphere reserve of this magnitude in this region. The ocean processes that influence the productivity of the banks and shelf, including the currents and temperature profiles which the currents influence, form a natural delineation in the northwestern Atlantic which the Cape and Banks Biosphere Reserve would roughly follow. Indeed, it may prove to be a characteristic of oceanic biosphere reserves, that they encompass significantly larger areas than their terrestrial counterparts, if only because of the differences in the scale of underlying ecological processes. Sea-surface temperatures highlight the continuity of the proposed area in showing that a uniform thermal regime frames this vast area at certain times of the year. Furthermore, significant stocks of finfish and populations of whales and dolphins, to which this coastal area is of such critical importance, stay within the area of the proposed reserve to feed and provide a living framework for delineation. A reserve of this sort would form as coherent an ecological unit as virtually any other marine area. The communities located in the coastal areas of both the southern and the northern flanks of this area utilize the same fisheries resources (centered primarily on Georges Bank) and are thus linked by a common vital resource base. Marine researchers

Figure 3. Outer limits of the proposed Cape and Banks Biosphere Reserve.

from both the U.S. and Canada have a long history of work in the greater Georges Bank area, so the area forms not only an ecosystematic unit but a corresponding research unit as well.

Special Areas Within the Biosphere Reserves

The MAB zonation scheme for biosphere reserves (UNESCO 1984) was developed for terrestrial environments and is not fully suitable for coastal and marine areas where the strict criteria concerning legal protection are difficult to meet. For this reason, the Acadian Boreal Panel has suggested defining the zones within its biosphere reserve selections to include:

- Core areas: Strictly controlled, land-based protected areas that occur within national, provincial, state, or private parks;

- Buffer zones: Less regulated areas surrounding cores in which limited and controlled resource use occurs, typically delimited by the boundary of a national park or other management unit;

- Zones of cooperation: The open-ended areas within the biosphere reserve, corresponding to "transition areas," which are regions of potentially cooperative scientific and educational activities; and

- Areas of intense ecological interest: Focal areas of the biosphere reserve, typically within the zone of cooperation, which are notable because of ecological importance but which cannot be called cores due to lack of legislative or institutional protection.

Each nominated biosphere reserve would have a full complement of these specially defined areas. What remains to be done, however, is to use available information to recommend the locations of special areas. In addition, feedback from a wider audience will be required to design reserves that can be implemented with public support to meet the program's goals. For this reason, the Acadian Boreal Panel is convening meetings of resource managers and park administrators in the area to elicit their input in forming practical working biosphere reserves. Public involvement will furthermore become increasingly more important as specific proposals for the reserves begin to take shape.

In addition to the unique opportunities that the planning and management of these potential biosphere reserves would offer to the members of the community in or near the region, the establishment of these multifaceted biosphere reserves would also facilitate the mitigation of external negative impacts on the critical areas of the reserves. By this we mean that the biosphere reserves will provide an important framework for investigating indirect effects on the ecological "health" of the region, such as the impact of riverine pollutants from source points far from the coast, or effects of hydroelectric activities outside the limits of the protected area. Due to the patterns of connectivity that link terrestrial and marine systems in the unique area that is the coastal zone, it is important that such "downstream" problems also be addressed (Ray 1976).

Thus, we feel that the areas we have targeted as critical to the formation of effective coastal and marine biosphere reserves and to the long range health and stability of the highly productive and ecologically important systems must be managed in a way consistent with the aims of the MAB Program. The Panel welcomes any comments on the selection of prospective Acadian Boreal Reserves; please address correspondence to either of the Panel's co-chairmen listed below:

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THE CONCEPT, PRESENT STATE, AND PROSPECTS FOR BIOSPHERE RESERVES

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ABSTRACT. This paper reviews the current status and development of biosphere reserves in the USSR and in the world. It is noted that the basic concept of the biosphere reserves has changed and if the system is to meet its goals, there is a need for change. The biosphere reserve concept must be better defined if the program is to accomplish its goals of contributing to the conservation of nature and to better defining the impact of economic development on natural systems.

KEY WORDS: Biosphere reserves, conservation, research, monitoring, global conservation.

The concept of biosphere reserves is based on the idea of a world network of protected territories, representing at least a part of the genetic and ecosystemic diversity of the biosphere (Third Session of MAB International Coordinating Committee (ICC), Washington, 1974).

Functioning as a single world system, this network seeks to coordinate on an international level the actions necessary to conserve the biosphere's genetic resources, conduct research aimed at refining both the conservation and use of biological resources, and develop forms of international cooperation in the conservation of nature and ecological education. This approach was subsequently supported in many countries, including the USSR and USA. The Soviet-American Governmental Communique for the Conservation of Nature (May 3, 1974) stated that the two countries are willing to expand cooperation in the conservation of the environment and contribute to the international Man and the Biosphere Program conducted by the initiative of UNESCO. The sides have agreed to set aside in their respective countries certain natural areas--biosphere reserves--for the conservation of their genetically valuable species of plant and animal life and their ecological systems, and to conduct the research necessary for more effective activities of man in conservation of the world environment.

Later, the concept of biosphere reserves naturally merged with the idea of global monitoring of the environment at the background level. In fact, those biosphere reserves least disturbed by development appeared to be the best territories for the establishment of long-term monitoring of changes in the state of biosphere components. At the First Soviet-American Symposium for Biosphere Reserves (USSR, 1976), monitoring was considered one of the purposes for establishing such reserves. This concept was recorded in the documents of the Fifth Session of the MAB ICC (Vienna, 1977), whereupon monitoring became the fourth objective of biosphere reserves.

The logical completion of the refinement of the biosphere reserve concept was, as proposed by the USSR at the Sixth Session of the MAB ICC, the First Biosphere Reserve

Congress held in 1983 in the USSR (the Sixth Session of MAB ICC, Paris, 1980). By the beginning of this Congress, the concept of establishing an international network of biosphere reserves had gained a wide recognition among the world community. At that time, about 200 biosphere reserves existed in 55 countries. Although a certain amount of experience existed in the organization of biosphere reserves, at times there was no agreement in the interpretation of their functions, locations, relationships, and interactions with regional problems. Moreover, representatives of a number of countries (for example, Finland, Sweden and others) did not see any principal differences between biosphere reserves and any other protected territories, which, in particular, manifested itself in the absence of legally designated biosphere reserves in these countries. The experience gained showed a great diversity in the approaches associated with national traditions, possibilities, research priorities, etc. In fact, in developed countries, the status of biosphere reserves was most often assigned to territories that were already previously reserved (national parks, preserves, zapovedniks, etc). In these territories, direct use of natural resources had been absent for a long time or was very limited. In some cases (for example, in the national parks of the USA that were assigned biosphere reserve status), intensive recreational activities were retained; while in the USSR's zapovedniks recreation was totally prohibited. Now it was necessary to integrate this diversity of forms into a single concept.

Territorial Structure of Biosphere Reserves

Territorial structure was for a long time one of the most debatable issues. To date, the concept of biosphere reserve zonation has been refined and advocated. According to this concept, a biosphere reserve is to consist of core, buffer and cooperation zones. Unanimously regarded as a core zone is the best-preserved natural area with the greatest diversity of gene pools and ecosystems, where development and recreation are totally excluded. Thus, the core zone provides for the conservation of gene pools and ecosystems and it is exactly here that basic research, which does not involve experimental manipulation of natural ecosystems, is conducted.

Although there is agreement on the understanding of the function of the core zone and its selection, there are considerable differences of opinion related to the specific situation of each country. In fact, in the densely populated countries of Europe, no undisturbed ecosystems have remained. When development is excluded from such territories, the ecosystems of these territories begin to be transformed and their diversity often declines rather than increases. The numbers of certain species sharply increase. With man's constant pressure, the established ecological relationships are disturbed; and undesirable changes in the structure of the ecosystems and their components occur. Under such conditions, the general conservation strategy is clearly unacceptable and goal-oriented management is required.

Understandably, this contradicts the general concept of the preservation of natural diversity. In fact, heated debates still go on in our country regarding the attitude toward a biosphere reserve's core zone. Some authors advocate absolute non-interference; others do not exclude the necessity of some degree of management. For example, to preserve the diversity of the meadow steppes of the Centralno-Chernozemny Reserve (situated in a densely-populated part of the USSR), mowing or moderate grazing is necessary. This requirement notwithstanding, the Centralno-Chernozemny indeed remains a biosphere reserve, as it protects the gene pools of meadow steppes and forest steppes that were once widespread but nowadays remain in very limited areas. Such situations are fairly typical of Europe and they cannot and should not devaluate the biosphere reserve concept. On the other hand, in the vast biosphere reserves of Siberia and North America one can exclude all land use, and this will not lead to any undesirable changes in the ecosystems. The Congress's materials have revealed that with the common understanding of the objectives of the biosphere reserve core zone--the preservation of diversity of the gene pool and ecosystems--a whole range of strategies ensuring the implementation of these objectives should necessarily exist, from rigid conservation to management simulating the pre-industrial, historically- formed relationships between man and nature. We have in mind such relationships that would not decrease but augment the diversity of the gene pool and ecosystems.

In accordance with the general concept, the core zone of the reserve is surrounded by a buffer zone. The general purpose of the buffer zone is to decrease the direct or indirect impacts of development on the core zone. Here, depending on particular conditions, recreation is allowed, as well as limited and strictly-defined development and experimental research, etc. Although the core zone concept is fairly well defined, the core zone status may vary depending on local conditions and traditions. For example, in a number of the USA's national parks, such sites are selected for the core zone where recreation is excluded. The remaining part of the territory is regarded as buffer. In the USSR, reserves have been established historically as territories in which no land use or recreation is allowed. This arrangement excludes zonation. Such zonation would be a step backward in the conservation of nature and would naturally devaluate the established concept of a reserve and reservation. Hence, in the USSR we set aside as a buffer zone a limited area around the reserve with limited development.

The idea of establishing a cooperation zone is primarily associated with the problems of the rational management of nature in developing countries. In fact, contradictions between biosphere reserves and local populations can be avoided only if the reserve's activities are of actual use to the local population and promote the socioeconomic development of the entire region. Such an approach is undoubtedly progressive. At the same time, conflicts between biosphere reserves and development exist not only in developing countries. Hence, orientation to a maximally effective interaction of nature conservation and research with development is also necessary.

It should be noted here that at the early stages of the concept and evolution of biosphere reserves, the USSR proposed integrating both the reserve and the system of development in a vast representative territory (Kovda and Kerzhentzev, 1977; Badenkov and Puzachenko, 1978). The first attempts to conduct research in such regions as Central Russia and Sikhote-Alin were made. There is every ground to believe that the basis of the biosphere reserve concept and its territorial organization are, on the whole, acceptable for the most diverse socioeconomic and natural conditions. But the particular forms of implementing the general concept and the whole scale of fulfilling particular objectives are closely associated with the history of the socioeconomic development of the region and its existing conditions. In this connection, we should actively criticize the dogmatic use of general ideas, and most importantly, we should regard the adaptation of these ideas to the particular conditions, keeping in mind the general objectives.

The Place of Bisophere Reserves in the System of Protected Territories

The modern network of biosphere reserves is characterized by extreme patchiness, both in the coverage of particular continents and in the sizes and natural features of biosphere reserves. Many biosphere reserves are located in Western Europe (except North Europe), and there are relatively few of them, for example, in Canada, China and the USSR. For example, as of 1984, Bulgaria had 17 biosphere reserves, Great Britain 13, Spain 9, Canada 2, China 3, and the USSR 17. Biosphere reserves have been established only in 62 countries. The areas of the biosphere reserves show similar contrasts--from several thousand hectares to hundreds of thousands of hectares. This qualitative heterogeneity reflects the instability of the biosphere reserve selection criteria and the differences in the interpretation of their general purpose. The modern network of biosphere reserves appears to illustrate the specificity of national approaches to the problem, rather than the commonness of the international concept.

There is a widespread view among specialists in nature conservation and reserves that any reserve or reserved territory is a biospheric one in principle. Adopting this viewpoint would unavoidably lead to considerable duplication in the conservation of gene pools and prevent assigning the greatest material and technical resources to the most important projects. Hence, a very loose interpretation of the concept "biosphere reserve" and assigning any territory to this category theoretically devaluates the biosphere reserve idea. The matter is complicated by the manifold purposes of biosphere reserves, which, in some cases, contradict each other.

National priorities are of importance. Small countries have smaller possibilities of selection than large ones; developing countries have fewer possibilities than developed ones, etc.

Actually, the difference between the network of biosphere reserves and the national networks of reserved territories should be in the same relationship as the International and National Red Books. The former includes only those species whose conservation needs are recognized as general international problems, while the latter lists species that are rare and need protection within national territories but are quite common beyond them.

In numerous discussions on the problems of selection of biosphere reserves in our country, it was contended that since biosphere reserves have top priority they may undermine the very concept of the network of national reserves in the USSR. The proponents of this view claimed that biosphere reserves, which drain the largest funds and the most qualified experts, would lead to a sharp decline in the quality of research and in the level of nature conservation in the other reserves. It should be noted that a certain discrepancy between biosphere reserves and all other protected territories (viewed as structural elements of an integral system) has never been practically considered in the MAB documents. It is quite evident that biosphere reserves do not exist as independent units. They are important and presumably represent the dominant structural elements of the total system of protected territories of the world. Hence, the hypertrophy of the biosphere reserve concept is dangerous and can be detrimental.

Analysis of the MAB Program materials gives grounds for concluding that Project 8 ("Conservation of Natural Regions and the Genetic Material They Contain") has been actually replaced by a more particular project called "Biosphere Reserves." Presumably, consideration of biosphere reserves outside the entire system of protected territories leads to drawbacks in the system of selection criteria and creates a lack of understanding of the idea of biosphere reserves itself. Without delving into theoretical problems of the hierarchical organization of complex systems, it will be noted that all the hierarchical levels of such a system have equal importance but different functions. Its elements-- in our case, the protected territories, of course---differ in their importance. The elements that belong to the upper biosphere level are relatively few, and in the final analysis, are unique and hence indispensible. The elements of the lower level are large in number and their properties are less individual and can be reproduced. The experience of our country supports the fact of the hierarchical structure of the organization of the network of protected territories. In the USSR, there are federal reserves which include territories with very interesting elements of nature. Also, there are republican reserves. And finally, there are local preserves. Thus, the resolution of the contradictions between the biosphere reserves and the entire national network of protected areas appears to lie in the development of the entire concept of the system, which would determine the strategy and tactics of the development of protected territories at each level and in every region.

Economic Aspects of the Establishment of Biosphere Reserves and Other Protected Areas

The establishment of protected areas whose resources are fully or largely excluded from development is one of the simplest and most effective strategies of the conservation of the sustainable potential of nature under a developed economy.

Theoretical estimates of the optimum portion of the territory to be protected, based on spatial and temporal changes in the diversity of ecosystems and related species, indicate that diversity can be practically fully retained if a protected area constitutes 7 to 15% of a territory, depending on a particular situation (Puzachenko and Drozdova, 1986). Estimates of the proportion of protected territories for the world (Europe without the USSR 3.9%, USSR 2.5%, North America 8.1%, South America 6.1%, Africa 6.5%, Asia without the USSR 4.4%, Australia 4.3%) indicate that it is 2 to 3 times lower than the optimal one; under such conditions, preservation of about 50 to 60% of the world's fauna and flora can be provided.

According to Soviet data, management of a fairly well-to-do reserve requires about $38,000 in main funds, the total annual expenditure being $51,000 (Krasnitzky et al., 1986). Taking into account differences in world prices and systems of financing, it can be assumed that for every square kilometer of protected territory, $40,000 is needed to provide the necessary protection and research. Consequently, to provide a present-day level of the world network of reserves, which should ideally constitute about 8% of the world's land, about $430 billion a year would be required. For example, in Africa this estimate would be $96 billion a year. It is quite evident that the allocation of such or similar sums for the protection of territory and research, aimed at monitoring and elaborating methods for rational land use, are impossible in the near future. Protection without research is much cheaper, constituting about 4% of the total expenditure of the reserve's activities. Hence, if conservation alone is organized, the annual expenditure will amount to $26 billion a year, and the expenditure for the countries of Africa would be $5.76 billion.

Since these calculations are only tentative, it is evident that the expenditure for actual protection of the necessary fraction of the world's land is in the order of billions of dollars, and no matter how we would desire it, at the present stage no material or labor resources can be allocated on an equal basis for the development of all existing reserves and other protected territories. This objective reality cannot be ignored. The concept of biosphere reserves, provided that it evolves in the right direction and is used correctly, promotes a concentration of capital investment in those areas that are the most essential socially and economically, and also the most valuable from the viewpoint of environmental protection.

Taking into account the great costs of the normal functioning of the network of biosphere reserves, we would recommend that the international coordinators of the program should rely on strict and substantiated approaches in their selection. Along with that for the biosphere reserves, this problem is yet unsolved and to date the criteria for selection are purely qualitative and auristic and the uncertainty of selection is very high.

Practical experience dictates the emergence of new forms. In fact, to avoid establishment of several biosphere reserves that duplicate each other or overlap functionally, the concept of cluster or analogue reserves was introduced into practice after the Congress.

Implementation of the Main Objectives of Biosphere Reserves

The strategy for gene pool conservation, under the concept of biosphere reserves, differs little from the one that functions traditionally in many countries. At the present time there is no single solution. The problem of determining the optimum area sufficient for sustainable existence of the populations of plants and animals and the biosphere reserve as a whole is yet open.

In the MAB documents, proposals were considered for the establishment of reserves communicating by means of protected corridors along the possible pathways of exchange between local populations. The natural evolution of this concept is the augmentation of the stability of a population and the preservation of its gene pool on the basis of exchange of individuals effected by man. The earlier study (Sokolov et al., 1983) and discussion of N. I. Vavilov's concepts of foci species diversity found reflection in the Plan for Action on Biosphere Reserves; it recommends that biosphere reserves should be established in territories that focus on high biological diversity and endemism as strategies for the most comprehensive of the world genetic resources, by a limited number of territories.

In the final analysis, the problem of gene pool conservation is primarily associated with a network of protected territories sufficient for maintaining the sustained existence of the populations under protection.

<u>Research</u> is the most important objective of biosphere reserves. In this respect, our country has accumulated considerable knowledge of world importance. It should be noted that in the USSR alone there exists a permanent staff of scientists, whose professional duties include conducting the most diverse studies, both in applied and fundamental fields. The main areas of research are those associated with the conservation of rare species; they are based on population theory and also on ecological studies providing

development of integrated mathematical models of the functioning of ecosystems for the purposes of predicting and managing natural resources. In this connection, top priority is given to the problem of inventory, creation of data banks and application of sophisticated methods of collection and processing of information.

Of particular scientific and technical importance is an expansion of research into the cooperation zone of a biosphere reserve. Studies conducted in these territories should, on one hand, be conjugated with activities in the core and buffer zones, and on the other aimed at a solution of the most essential economic problems of natural resources in a given country and their rational intensive utilization.

The organization of global monitoring at the background level can be a major contribution of biosphere reserves. As can be seen from experience, it is comparatively simple, both theoretically and technically, to organize direct instrumental monitoring of the state of the atmosphere and hydrosphere. A much more complicated task is to study the reaction of biota to changes of background values in the concentration of industrial pollution products. Some individual objects, such as lichens, demonstrate high sensitivity to changes in the levels of technogenic pollution. Structural parameters of both ecosystems and their individual components have a high stability and only rarely do they yield well defined adequate responses to small external turbulences. Also rather promising is the use of objects capable of constant accumulation of the products of industrial pollution and their concentrations, either in given parts of the organism (for example, in the chitinous integument) or in definite components of the ecosystems (for example, in the peat from bogs). Apparently, scientific and technical studies in this field should develop actively. It should be noted that in world practice, long-term observations of ecosystem components are quite limited and are rarely associated with protected territories. In this connection it is not accidental that the "Nature Record" traditional for our reserves is regarded as an analogue of ecological monitoring. With all its shortcomings and incompleteness--and even patchiness--natural records are of great importance and are of world value. Our task is to make them accessible for the world community.

In addition, the need for ecological education is regarded, in world practice, as one of the most important objectives of biosphere reserves. In our country, ecological education is traditionally accomplished through visits to reserve museums, lectures by reserve workers, education of students in the course of their practice, etc. In some reserves there are clubs of young naturalists. However, our reserves are far from attaining all their potential in the field of ecological education and training. The experience of such countries as Canada and others demonstrates the ample possibilities of ecological education through ecological trails and routes established in many national parks of developed countries.

The Problems of Management

Also of international importance are the problems of managing protected territories. The essence of the problem is the organization of reliable protection and cooperation with local administrative organs, the local population and the system of nature management. The status of biosphere reserves is in many cases not ensured by legal acts. Usually there is no legal system regulating relations in the cooperation zone. In various countries these problems vary in their acuteness, but they have been solved nowhere; this naturally has a negative impact on the activities and development of a biosphere reserve. The problems of relations with local populations are also acute in developed countries. But it is still more acute in developing countries, particularly in forestry and in grassland livestock husbandry.

In addition, reserves often have conflicts with polluting industries. This problem also appears in the USSR, too, despite its system of state planning. These problems are not the result of some subjective factors; rather, they reflect the contradiction between the purposes of extensive development and nature conservation. The resolution of these contradictions is possible, on one hand, by striving to refine the norms that regulate legally complicated territorial relations; on the other, by developing the theory and practice of law in the field of nature conservation in general, with special reference to protected territories and to special objects or species in particular; and, finally, on the basis of the long process of social-economic development aimed at comprehensive intensification of land use with a careful and maximally economical, highly technological and ecologically acceptable use of the resources.

Analysis of the legal state of reserves in general and biosphere reserves in particular demonstrates the importance of scientific design with special reference to reserves, which would substantiate the objectives of the reserves, organize the system of their cooperation with other agencies in the solution of important regional problems, substantiate and prepare legal documents concerning the boundaries of the core, buffer and cooperation zones, and determine the functions and duties of the partners in each of these zones. Under this design, it is necessary to substantiate the program for logistic and staff support, and build capital to meet the particular objectives of a given reserve. Attempts to solve these problems under the standard statutes of biosphere reserves before all this work is done are futile. There is much legal uncertainty here.

Thus, analysis of the success of and the existing problems in the development of the network of biosphere reserves, both in this country and in the world, demonstrates that the whole concept is now in the state of formation. But gradually experience accumulates, promoting elaboration of long-term solutions and recommendations, which gives reason to hope that the world community will, in the near future, reach certain success in the implementation of the short-term Action Plan for Biosphere Reserves, as adopted at the First International Congress.

THE USE OF THE USSR BIOSPHERE RESERVES IN IMPLEMENTING INTEGRATED BACKGROUND MONITORING OF THE STATE OF BIOTA

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ABSTRACT. Assessment of changes in the state of biota resulting from environmental pollution is one of the most important objectives of ecological monitoring. Spatial and temporal scales determine the pecularities of implementation. Symptoms of damage to biota should be examined on the local level (in impact zones) along pollution concentration gradients, revealing their dynamics over reasonably short periods (about 1 year). Standard biological observations should be implemented on the regional and global levels in representative biotest sites remote from pollutant emission sources in order to indicate regional ecosystem responses to background pollution (time period about 3–5 years). A minimum program is proposed to include observations of the species composition and density of epiphytic lichens, observations of the index of primary production of terrestrial ecosystems, and observations of pollutant bioaccumulation by biological land cover. The UNESCO biosphere reserve network should be used as a system for early detection of global changes in the state of biota, including those due to global and regional environmental pollution. It would be expedient to use this global network of biotest sites for implementation of the minimum biological observation program.

KEY WORDS: Forest ecosystems, priority pollutants, lichen survey, natural areas, biosphere reserves, biological indicators, biotic response, bioaccumulation.

The effect of man-made impacts of various types, including atmospheric pollution, on terrestrial ecosytems has become pronounced. Thus, forest ecosystems in a number of regions, such as western and central Europe, are endangered. In other cases, certain trends in forest dynamics arouse concern despite the absence of indications of acute plant damage.

All this justifies the need for ecological monitoring of terrestrial ecosystems, not only by geophysical but by biological indicators as well.

In this connection, modern ecology faces numerous problems of fundamental and applied nature (Izrael 1979, 1984; Sokolov and Smirnov 1980). The experience gained thus far in environmental monitoring is related mainly to the sphere of impact monitoring. In both the USSR and other countries, observations of anthropogenic impacts due to urban pollution have been carried out in recent decades near industrial enterprises, i.e., on the local scale. Monitoring has been carried out both directly with respect to the levels of pollutants contained in environmental media, and through biological indicators of the state of natural ecosystems exposed to unfavorable man-made influences.

It might be pointed out that relevant back-up methods for the latter direction are quite sufficent (Izrael et al. 1986). Certain organizational efforts within the Convention on Long-range Transboundary Air Pollution of the United Nations' Economic Commission for Europe (UNECE) have been undertaken recently for arranging regular forest state surveys in the region that estimate impact intensity and related damage.

As for global-scale monitoring, the situation is somewhat different. Very large areas under conditions of background pollution are not suitable for regional biological observations on a regular 4 x 4 km mesh network, as recommended by UNECE experts. Therefore, the background ecological observation network for early warning of man-induced changes, now being created in the USSR, is based on different principles. So far, the abiotic observation program currently being implemented in the USSR involves integrated background monitoring stations (IBMS) operated under the USSR's State Committee for Hydrometeorology and Control of Natural Environment (Rovinsky et al. 1985). However, the development of relevant biological observation programs and their incorporation into environmental management practices has encountered serious methodological difficulties, which require related research (Insarov and Filippova 1985; Insarov et al. 1985; Fillippova et al. 1982; Izrael et al. 1985; Izrael et al. 1986; Razumovsky 1980; Razumovsky 1986; Izrael et al. 1980).

In this paper, we discuss the methodological aspects of developing biological methods for regional and global background environmental monitoring and the probable scope of these techniques within relevant programs, as well as some pertinent observations.

Methodological Aspects of the Problem

One of the most typical problems of impact monitoring is the separation of the impact zone or zones from a given source of pollutant emission. Distinguishable spatial gradients of impurity concentrations in the atmosphere, occurring near large emission sources, ensure a sufficent reliability in the separation of relevant zones; for instance, by the difference in the degree of vegetation damage (zones of acute damage and zones where damage is not visually detected). When a new enterprise is put into operation or its capacity is growing, temporal changes in zone dynamics might be observed. The concentration gradient may be so high, both in time and space, that the pollution zones can be easily detected despite the patchiness and time-spatial inhomogeneity of the ecosystem near the impact source. Natural variations in the state of biota (noise) appear to be insignificant compared to the "signal" (change in the extent of man-inflicted damage on biota along the spatial gradient of impurity concentration or at a space point in time).

The latter circumstance makes the conventional approaches, approved for impact monitoring, correct and understood: identification of the relationship between the source's intensity and the damaged zone area; selection of reference trial sites for observations along the gradient of impurity concentrations; impact source zone mapping by geophysical and biological indicators; and so forth. The usual scope of this situation is local---for example, a hundred kilometers from the emission source.

As for regional and background global monitoring of environmental pollution and its ecological effects, the situation is quite different. The characteristic spatial scale here is thousands of kilometers; there are no localized pollution sources; the source is the entire atmosphere; and no distinct gradients of background atmospheric pollutant concentrations are observed over land on the regional or continental scale.

Thus, the portion of anthropogenic pollutant emission that is bound to induce a change in the regional and global impurity content in the atmosphere will bring about a somewhat ubiquitous, homogeneous change in the level of loading on terrestrial ecosystems. The spatial gradient of the loading is inexplicit, while the change in the level of the loading with time (signal) is low when compared to the "noise" (temporal-spatial variability of the state of biota).

Though man-induced regional- and global-scale changes are insignificant, they should not be ignored. Sharp impact effects occur on small areas, while regional and global effects, being not acute, occur over vast territories. Integrated estimates of these effects show their compatability in terms of ecological and economic consequences (Filippova et al. 1982).

The responses of different continental ecosystems to nearly the same background pollution impact are not identical. To understand the effect of background pollution at the scale of a continent or a large region, pertinent ecological zonation is required; in other words, the territory under study is subdivided into homogeneous areas, in which the natural ecosystems respond to a given level of man-induced pollution as well as to other ubiquitous anthropogenic stresses within the separated areas in a similar way, though differently in individual areas.

There are various schemes of ecological zonation. In our opinion, botanico-geographic zonation, carried out by S. M. Razumovsky (of the Natural Environment and Climate Monitoring Laboratory under Goskomgidromet and the USSR Academy of Sciences), meets the goals and objectives for monitoring the responses of terrestrial biota to background regional and global environmental pollution (Razumovsky 1980, 1986). It is based on the similarity of phytocenotic successional processes within separate areas, which allows us to expect homogeneity in plant cover transformations in response to given changes in the background pollution of the environment. The characteristic scale of these separate botanico-geographical areas is about 1000 km.

Implementation of systematic detailed observations of the state of terrestrial ecosystems at these scales is, of course, not feasible. Therefore, it is necessary to separate a special biological site (or a number of sites) within the limits of each botanico-geographical area to carry out such observations. The natural conditions and diversity of the ecosystem types of these sites should, to a maximum extent, represent the characteristic natural conditions and ecosystem diversity of the whole botanico-geographical area. The area of a single biological site should be on the order of 100-1000 km^2 to ensure sufficiently representative and stable averaged characteristics of the state of biota.

To establish a system of continuous observations of the state of ecosystems at the chosen biological sites, it is necessary, first of all, to determine the composition and schedule of observations, the indices to be measured, and the measurement techniques.

Indices, conventionally used in ecological practice, usually involve such characteristics as densities of the populations composing biocenoses, such as species numbers or biomass per unit area and occurrence and density; as well as indicators of changes in time, such as birth and death rates, the rates of biomass production, shedding, destruction, and so on. These indices might be averaged to the scale of a site, or when required, to a larger scale within the site on a landscape-typological basis.

The chosen sites should be isolated to the maximum extent from local man-made impacts (including pollution) and should be located in territories with no economic activities in order to provide for a continuous series of observations. These requirements are necessary for distinguishing regional- and global-scale effects.

The most adequate biological sites for environmental observations in the USSR, which meet the above stated requirements, are the territories within state reserves and some other reservations.

The methodology of full-scale measurements should be based on the now developed set of methods for measuring the numbers and biomass of biological populations and relevant demographic and production-destruction characteristics. Among numerous examples, we shall point out the widely applied lichen survey methods of Insarov et al. (1986), methods of recording the numbers of needle- and leaf-insects (Golubev et al. 1980), methods of analyzing woodstand dynamics (Antanaitis and Zagreyev 1981, Juknis 1985) and of production-destruction processes (Bazilevich and Tishkov 1983).

Although we emphasize measurements of purely ecological characteristics, we do not deny the necessity of using other parameters as well, such as the physiological parameters for monitoring probable pollution effects.

Minimum Program of Biological Observations at Background Biological Sites

A standard program of observing the response of biota to the impact of regional- and global-scale environmental pollution should take place at all the biological sites in a standardized regime, and hence, it cannot be excessive. The reasons are numerous, but we shall recall the following. Biological observations, unlike geophysical observations, are poorly automated; hence, adequate data collection requires considerable effort and time. Recall that it is not a point measurement of a biological parameter that is considered a typical "regime," but its average over a fairly large area of the site. Adherence to biological methods requires a comparatively high qualification, which makes the implementation of expanded programs of systematic observations at the first stages rather complex. So *in situ* training of specialists is needed. Future extension of the program should take into account the experience gained in the implementation of the minimum program. Proceeding from the above and taking into account recent research results, a minimum list of standard field observations might be proposed for background biological sites (Table 1).

At present, the expediency of including some other observations into this list is being examined, such as the health of stands by ecological, mycologic, entomologic, and other characteristics. Here we also stress the importance of remote sensing techniques, including air-space methods.

Table 1. Minimum list of the types of observations at biological sites.*

Observations	Reason for inclusion	Methodological back-up
1. Lichen survey to obtain quantitative characteristics of the state of epiphytic lichenoflora	High sensitivity of epiphytic lichens to atmospheric pollution, combined with low inherent variability	Elaborated general methods for collecting lichenometric information; need improvement and adaptation to regional conditions
2. Measurement of organic substance production and destruction in ecosystems (particularly the tree layer), including indicators of increment, shedding, and state of woodlands	High economic value of these indices, their key role in ecosystem maintenance, and their significance in understanding global biosphere processes	Available conventional biological methods of measuring indicators of production and destruction in terrestrial ecosystems, particularly forest ecosystems. Need improvement to increase resolution; physico-chemical "non-destructive" control methods need to be developed and adopted on the basis of research on substance circulation in terrestrial ecosystems
3. Measurement of the flux of priority pollutants absorbed by biological land cover, including vegetation	Importance of air, water and soil protection capacity of biological cover, including vegetation, on regional and international scales	Available physicochemical measurement techniques; need improvement and adaptation to specific regional conditions

* These proposals have been elaborated with the participation of G. N. Voronskaya, N. M. Zhloba, I. J. Nikolishin and B. N. Fomin.

Table 2. Estimates of the state of epiphytic lichenoflora in the USSR natural reserves.

Reserve	Sampling height (m)	Year	Average cover	Rate of variance
Sary-Chelek	1	1980, 1981*	0.13	0.28
	1.5	1980, 1981*	0.14	0.22
Sikhote-Alin'	1.5	1978	0.12	0.22
Kronotsk	1.5	1980	0.08	0.81
Berezina	1.5	1980	0.37	0.10
Caucasus	1.5	1982	0.24	0.19
Repetek	0.5	1979	0.017	0.46

* Estimation from data combined from 1980–1981.

Figure 1. The USSR reserves, in which lichen surveys have been implemented:

1. Berezina (1980)
2. Central-Chernozem (1981)
3. Caucasus (1982)
4. Repetek (1979, 1981)
5. Sary-Chelek (1980, 1981, 1982)
6. Sikhote-Alin' (1978, 1982)
7. Kronotsky (1980)
8. Sayano-Shushensky (1981)
9. Kandalaksha (1984)
10. Kopetdag (1984)
11. Suint-Khasardag (1984)
12. Chissar (1983)
13. Lithuanian SSSR National Park (1986)

Some elements of the program presented in Table 1 are currently under various stages of methodological improvement and realization. The less developed is the third part (see Table 1); its implementation requires labor-demanding, simultaneous measurements (though fraught with errors) of biomass fluxes within an ecosystem and concentrations of various priority pollutants in its components. An optimum methodological approach has not been developed so far.

Dendrometry techniques (the second part of the program, Table 1) have been well developed. Special techniques have been developed (Juknis 1985) for background biological sites in the USSR, which enable us to stratify forested areas to make a rational choice of test stands inside strata and of test sites inside the latter, as well as to inventory these units (blocks), including core sampling. The techniques have been verified in the Berezinskyi Biosphere Reserve (Belorussian SSR) and Lithuanian National Park, and now will be introduced for practical application in the USSR.

Lichen surveys (the first part of the program, Table 1) have been in progress for some time and are now widely implemented (Insarov et al. 1986).

Establishment of the system of observations for epiphytic lichens stems from the need for comprehensive and accurate information on various biomes (Insarov et al. 1986). The program is an especially cost-effective one in view of funding shortages for research. Observations are carried out in natural reserves, located in background regions for atmospheric pollution, including those that have been given the status of UNESCO Biosphere Reserves (Fig. 1). Observations in the reserves include registration of lichens on trees of the major forest-forming varieties; the trees are grouped into samples. The number of test sites depends on the time available for expeditions and on the characteristic features of the reserve under study. The test site arrangement should be regular with due regard to the abiotic and biotic characteristics of the territory.

There might be various applications of the obtained information. For each reserve we have obtained estimates of average density, expressed in percentages by trunk cross-sectional circumference at standard height (Table 2). Estimates of variance in average density have been obtained using a special statistical procedure with due regard to initial data correlation over the territory; the rate of variance is within 10-50%. This implies that it would take over seven years of annual observations to identify with 95% confidence the trend in the change in average lichen density; the rate of change has doubled in 20 years, and the rate of variance has been 10%. Note that the feasibility of increasing the technique's resolution by increasing the frequency of observations is restricted because the results of the observations correlate.

Conclusions

The reported approach to establishing the system of background biological observations finds application not only in this country. The International Workshop on GEMS Problem XII of scientific and technological cooperation of the CMEA member states, as well as the meeting of the Provisional Working Group of Experts, held in Vilnius

(USSR) in March 1987, gave major consideration to the forest background biological monitoring system.

Participants of the International Workshop recommended that the following biological observations be included in the program of background monitoring of the state of forest ecosystems:

- Lichen surveys: quantification of species composition and density of epiphytic lichens, attached to tree trunks, possessing the most characteristic ratio between their sensitivity to atmospheric pollution and their inherent variability;

- Measurements of production-destruction indicators in forest ecosystems, i.e., measurements of the rate of the most ecologically significant natural processes affected by anthropogenic influences (in particular, through implementation of dendrometric tree growth observations); and

- Measurements of the fluxes of priority pollutants absorbed by plants from the atmosphere in the course of bioaccumulation, i.e., assessment of the atmospheric protection function of the plant cover.

Experts of the Provisional Working Group have stated that the available software and back-up methodology for background monitoring of terrestrial ecosystems by biological indicators provide a reliable foundation for decision-making with regard to the start of routine background biological observations.

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BIOSPHERE RESERVES IN DEVELOPED COUNTRIES: THE CANADIAN EXPERIENCE[1]

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ABSTRACT. When establishing biosphere reserves, close attention must be paid to the human factors that make them work. Consultation processes are essential to obtain local understanding and acceptance of the concept, and to develop local organizational arrangements that will develop various biosphere reserve functions. Issues and experiences from striving to do this in Canada are discussed. Canada/MAB has prepared a "National Action Plan for Biosphere Reserves in Canada," modelled closely on UNESCO's global action plan. Four biosphere reserves already exist and nominations for two more are underway. In Canada as elsewhere, there is a need to develop fully-functioning biosphere reserves in different settings to provide good working examples of the potentials inherent in the concept. North America should be a leader in this.

KEY WORDS: Canada, Canada/MAB, biosphere reserves, national action plan.

Introduction

There are four established biosphere reserves in Canada. Consultation processes are underway to develop nominations for two more. Comments on our Canadian experience in trying to apply the concept of a biosphere reserve in practice will draw primarily on these six examples.

Unfortunately, and unlike the United States, Canada does not have a special agency with staff and funds to develop a Canada-wide network of biosphere reserves. Efforts to promote biosphere reserves are carried out through one of the "working groups" convened by the national committee, Canada/MAB. Of necessity, these working groups rely almost entirely upon volunteer commitment from their members, combined with small amounts of expense funds to help promote MAB in Canada. Through these working groups, Canada/MAB helps strengthen or complement ongoing activities of different agencies and organizations throughout Canada, whose programs are consistent with the goals of MAB.

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[1] An earlier version of some of this paper was published in the proceedings of the "All-European MAB Conference on European Biosphere Reserves and Ecological Monitoring" (Czechoslovakian Academy of Science, 1987). The views expressed are those of the author and do not necessarily reflect a consensus of Canada/MAB.

The Working Group on Biosphere Reserves currently has nine members. Four are representatives from the management committees of each of the biosphere reserves, four others are from government agencies which could authorize nominations for new biosphere reserves especially from northern Canada, and the writer is its chairman. One member of the Working Group has served with the MAB Secretariat in Paris on secondment from Parks Canada in 1983–1985.

Organization and Management of Biosphere Reserves

The Challenge of Getting Them Established

We have found it necessary to take a rather pragmatic approach towards eliciting nominations for new biosphere reserves in Canada to add to the global network. This is to take into account some of the prerequisites for developing a fully-functioning biosphere reserve. For example, if only landscape features were considered, then Canada has a rich array of possible biosphere reserves; many could be developed around a long-established park or other protected natural area. The real question however, is how to identify, from among a number of areas that meet biophysical criteria for a biosphere reserve, those which are also set in situations conducive to accepting the concept and realizing it in practice. Unless the idea is seen to be useful for resolving resource or environmental management questions by those who would have to make it work, a biosphere reserve designation would likely achieve few results. Therefore, time, care and persistence are required to help lay the necessary groundwork.

Rather than just waiting to receive applications for nominations, Canada/MAB, through its Working Group on Biosphere Reserves, initiates consultations about some areas it judges to be good potential candidates for biosphere reserves. These areas are well known for their natural features and values; they either have a history of field research or the potential for developing it along MAB lines; and they have conservation, resource management, or nearby development issues which require or might benefit from more extensive cooperation among various agencies and groups to deal with the issues more effectively.

Because legal and administrative arrangements have to be in place to protect the "core area" of a biosphere reserve before a designation can be received, the consultation processes fostered by Canada/MAB determine the form and acceptability of the additional arrangements needed to involve owners, managers and user group interests from areas outside the core. Fully functioning biosphere reserves require this; hence the perceived need to negotiate the basis for such cooperation as soon as possible, preferably right from the start.

In Canada, two major challenges have to be faced. One is to "sell" the concept of a biosphere reserve to local people. The other is to develop viable biosphere reserve management committees and programs. Both have to overcome the fact that the concept often seems too nebulous and abstract; the incentives for managers and local people to work with it are weak, and the organizational implications in some instances can be difficult to pursue.

Our experience has been that the terminology used by UNESCO/MAB to describe the concept is one source of initial perception difficulties. It is best to avoid references to different categories of "zoning" when talking with local people. Instead, we emphasize that the "reserve" part of a biosphere reserve is really the already established protected area. What is new, is that a "zone of cooperation" around this reserve is being considered in order to help people work on issues of shared concern; that participation in activities is entirely voluntary and often quite informal; and that the concept is expressed through whatever cooperation is mutually agreed upon and not by some zoning configuration (having no legal status) imposed on the cooperators' lands.

Management arrangements which reflect this perspective have been worked out at the Waterton Biosphere Reserve, and similar ones are being adapted for the others. In Waterton, two committees were established. One is a management committee composed of eight local residents and two staff from the national park, the latter being viewed as the core area. This group is responsible for defining objectives and programs; it organizes public meetings in part to discuss certain land and resource management issues, and it decides on research priorities. A technical committee reporting to the management committee is currently made up of 15 persons from different government agencies (including a representative from the adjacent Glacier National Park in Montana). This group reviews the technical merits of proposals received by the management committee, helps develop and implement biosphere reserve programs, and promotes interest among research personnel about opportunities to work in the biosphere reserve.

Issues of long-term support for biosphere reserves also have to be addressed, and they too usually come up early in the informal consultations. Since there is no central biosphere reserve agency in Canada, support has to be obtained from a number of sources to develop the activities for each biosphere reserve. The experience to date is that special efforts have to be made to cover initial expenses as the idea of a biosphere reserve is being developed. As it becomes accepted, then support begins to come from some re-direction of research, monitoring and educational activities by the cooperating agencies and non-governmental groups. Research and related activities are also supported by science funding agencies and private foundations. Although provision of funding support for biosphere reserves will require continual effort, this should prove easier to obtain as their roles become better understood and accepted locally as well as nationally.

The Conservation Role

Canadian biosphere reserves do help conserve interesting flora and fauna, including a few species listed as threatened or endangered in Canada. Their ecosystems are also presumed to be characteristic of the particular biogeographic provinces in which they are located. There are two main issues to be resolved in order to obtain a much more refined assessment of the actual conservation role of these or other biosphere reserves.

One is that biosphere reserves cannot be usefully assessed for their conservation of key species and ecosystems in isolation from all the other United Nations (IUCN) categories for "conservation area management" in some particular geographical region of interest. Conservation assessments must take into account the collective efforts and accomplishments of a number of agencies and organizations providing, in the case of Canada, a large number of national, provincial and territorial parks; a variety of wildlife conservation areas; special recognition for ecological reserves; and various other arrangements to protect certain landscapes deemed to be "environmentally significant" areas.

The other issue is that of developing a working classification of ecosystems. While biogeographic provinces constitute a useful beginning on a global scale, there are difficulties to be resolved in relating them to ecosystem classification schemes being used at national and sub-national levels. In Canada, for example, several classification systems of natural or ecological regions are being used in different jurisdictions to help determine priorities for establishing new parks or ecological reserves. Other classification systems have been proposed. All have been conceived at varying levels of scale and detail, with differing emphases on the relative importance of climate, landforms, vegetation and fauna. None mesh well with the system of biogeographic provinces.

Fortunately, some aspects of these issues are being addressed by groups other than Canada/MAB. The "Committee on the Status of Endangered Wildlife in Canada" carries out assessments at the species level of concern (Cook and Muir 1984). The "Canadian Committee on Ecological Land Classification" has developed a hierarchical framework that provides for an orderly meshing of classification schemes at six different levels of scale and detail (Rubec and Wiken 1984); the most generalized level ("ecoprovinces") is roughly equivalent to the scale and detail of biogeographic provinces, but they are not spatially identical.

The Logistic Role

One of the major roles for biosphere reserves is to provide the sites and support for management-oriented ecological research and monitoring. Developing effective support for this is particularly difficult in Canada because of the inherent scope and interdisciplinarity of the work required, and the need also to relate science to the needs of managers and particular concerns among local residents.

With this in mind, Canada/MAB has pursued two lines of activities. One is to draw together an account of what is known about each biosphere reserve as a result of past surveys and research. The other is to arrange some process of consultation for deciding priorities for future work. The means taken to do this have varied somewhat in each of the four biosphere reserves.

Canada/MAB has provided some funding for the preparation of annotated bibliographies. The bibliography for Waterton, prepared at the University of Waterloo, listed some 800 items relating to a region extending 50 km outside the core area within Canada which was of interest to the biosphere reserve committee. (US/MAB contributed to the preparation of a bibliography for the adjacent Glacier Biosphere Reserve). The Mont St.-Hilaire bibliography, prepared at McGill University in Montreal, has compiled over 140 papers and about 50 student theses pertaining to the 1100-hectare site of Mont St.-Hilaire (Levy and Lechowicz 1987).

At Long Point, an inter-university research group prepared a "Prospectus" (Francis et al. 1985) which has been distributed widely to the recently formed biosphere reserve committee and other interested persons. This prospectus developed a conceptual model of the Long Point ecosystem complex using concepts from biogeography, trophic dynamics, and stress-response ecological analyses. It examined institutional arrangements for managing the complex (which consists of 17 distinct ownership and management units plus one area of intensive cottage development) by identifying the mandates, policies and programs of eleven government agencies with reference to the ecosystem model. It also reviewed management questions about allocation of rights to resource use in the Long Point complex and policy mechanisms for making such allocations.

For setting research priorities, Mont St.-Hilaire, which is a long-established university research site, is leaving this question primarily to the judgement of academic scientists. The bibliography will assist this by indicating opportunities for research which could assess changes over time based on prior work. Waterton adopted a more broad-based consultation which led to defining priorities and the creation of the technical committee to help with implementation and follow-up. The bibliography would be primarily of use to individual research personnel who become involved with priority topics. The Long Point committee, which came together in late 1985, is still considering questions about its priorities and means to pursue them. Riding Mountain appointed a chairman for its technical committee along with other members to help with priority subjects of interest concerning watershed studies, wildlife and agriculture. Seven studies are underway.

As noted previously, the funding of research will vary depending on the topics chosen. Some will come from re-directing the ongoing work of agencies towards biosphere reserves, but some will also have to be developed as separate project proposals and submitted to different funding agencies. It is also expected that graduate student theses will be an important component in the research which gets done.

Much that was noted under research applies also to monitoring, especially monitoring directed towards ecological trends and fluctuations within biosphere reserves themselves. Environmental monitoring for other purposes, such as for ambient air and water quality, is conducted by different regulatory agencies. Their design of data gathering networks for these purposes do not necessarily include sites within biosphere reserves. One review of the suitability of biosphere reserves for integrated environmental monitoring in a global network identified Waterton as a site meeting requisite criteria (Wiersma 1987), but there are no arrangements in place to follow-up on this.

Environmental education and training activities are another important role for biosphere reserves. Fortunately, the four existing biosphere reserves and two new candidates being explored all have a well-developed base for this. For example, Waterton and Riding Mountain have national parks as their core areas and, like most national parks in Canada, have excellent visitor centers with "interpretive" programs on a wide range of nature conservation and outdoor education topics. Mont St.-Hilaire has one of the best non-governmental conservation education programs in Canada; it receives over 100,000 visitors annually, including many school children from both the French and English language schools in Montreal. At Long Point, several organizations associated with the new biosphere reserve group sponsor public information activities concerning different features of the Point and its wildlife.

The main need now is to add or strengthen a MAB component into these ongoing education and information programs. As the other biosphere reserve functions become developed, they will provide good examples which can be used. At the same time, it would be helpful to draw upon readily available information about UNESCO/MAB, and obtain up-to-date information on the development of other biosphere reserves around the world. This could be presented locally as good examples of the concept being applied in practice under a wide range of different circumstances.

With regard to training university students in ecology, Mont St.-Hilaire has residential facilities that are used each year for field studies by students from different regional universities. The other biosphere reserves do not themselves have residential facilities specifically for this purpose, but they could be used as appropriate sites for training courses. Again, it is mainly a matter of developing the other functions of biosphere reserves first so that good on-site examples of a fully-functioning biosphere reserve could become a focus for the training courses.

The public information role is also important. A start has been made on this in Canada, although much remains to be done. In 1982, we published a small question and answer brochure in English and French, and another in English and Inuktitut in anticipation of applying the concept in three biogeographic provinces within the Inuit (Eskimo) homelands. The first version (English and French) has been widely distributed, and is particularly helpful for consultations about possible new biosphere reserves. It now needs to be revised.

Waterton Biosphere Reserve published an attractive brochure in 1985. It described the concept of a biosphere reserve; explained the arrangements developed at Waterton for its management and technical committees; summarized the goals and objectives of the Waterton Biosphere Reserve; and outlined briefly the ten main projects underway. This brochure was quite popular and was soon out-of-print. Another revised and updated one is now available.

In addition, two papers about biosphere reserves were published in a Canadian academic journal (Lieff 1985; Francis 1985), and the concept of biosphere reserves is now mentioned with some regularity in various seminars or conferences dealing with natural heritage protection in Canada. Nevertheless, much still remains to be done for information and communication about biosphere reserves. Opportunities to do so should increase as the functions of existing biosphere reserves become better developed and new biosphere reserves are established in the Canadian network.

Finally, mention should be made of the MAB posters (UNESCO/MAB 1981). These have been used at various community meetings in different parts of Canada to talk about biosphere reserves. They have been particularly helpful for indicating how local participation in a biosphere reserve can also be viewed as part of a much larger global community of shared ideals and shared concerns.

The Development Role

The contributions of biosphere reserves to regional planning and resource management are critically dependent on the local cooperating arrangements put into place for each biosphere reserve. In Canada the "zone of cooperation" concept has allowed for different arrangements, hence different ways of responding to or assisting with development issues.

Two kinds of activities are developing. One addresses broad issues of mutual concern which the biosphere reserve committees can help resolve by providing a neutral forum for consultations, as well as facilitating the necessary applied research to help make rational decisions. This is the main role being sought for and by biosphere reserves in Canada. At Riding Mountain, for example, the main emphasis of the emerging biosphere reserve program is on watershed management questions (the core area contains headwaters for five regionally important rivers) and on a variety of problems between wildlife protection and agriculture in the zone of cooperation. These arise from the movement of some of the larger mammals, such as bears, wolves, and elk (wapiti) out of the park and into the adjacent agricultural lands.

The other kinds of activities are "interventions" into certain planning and development decisions themselves. Waterton has done this twice. There, the biosphere reserve management committee on its own behalf spoke out against a proposed recreational development on agricultural lands near the core park area, and on another occasion urged a provincial regulatory agency to strengthen the environmental assessment requirements before authorizing exploratory drilling for natural gas at a site within the "zone of cooperation" of the biosphere reserve. Both interventions helped bring about their desired results. These kinds of initiatives are potentially contentious. Yet they may well be increasingly necessary to give the local leadership needed for ecologically sustainable development.

Otherwise, the role of biosphere reserves in promoting ecologically sustainable development or resource use in the regions surrounding them remains critically dependent on the development of their research, monitoring, education and information activities. For the foreseeable future, this will have to be a priority for developing fully-functioning biosphere reserves in Canada.

Expanding the Canadian Network

Action Plan for Biosphere Reserves in Canada

Over the past year or so, Canada/MAB (1987) prepared a national "action plan" in response to the global Action Plan for Biosphere Reserves and other cooperating international agencies. The national plan has no authoritative status, but it does identify the main directions Canada/MAB will try to pursue in the years ahead.

We envisage two parallel lines of activity that will of necessity have to be pursued opportunistically in cooperation with a number of agencies and groups. One would strive to develop the full array of functions in existing biosphere reserves to the point where two or three of them might be able to participate constructively in the new research themes being developed through UNESCO/MAB (1986). In due course, some might also serve as "biosphere observatories" for the new International Geosphere Biosphere Program (IGBP) of ICSU. We are convinced that good operating models of "biosphere reserves in action" are the key to "marketing" the concept.

The other line of activity is to pursue nominations for new biosphere reserves. For discussion purposes, we said we should aim to have 15 biosphere reserves in place in 10 years' time.

Canada would contribute substantially to expanding the global network of biosphere reserves if we could establish at least one biosphere reserve, perhaps as a cluster, in each of the nine biogeographic provinces that have over 50% of their area in Canada. Since this would require five north of 60+, the feasibility of developing fully-functioning biosphere reserves in the more remote regions of the country has to be considered. Northern biosphere reserves especially would have to involve different native peoples in local management committees, and arrangements for this may well have to await satisfactory negotiations of land claims in light of our constitutional recognition of aboriginal rights.

Possibilities for marine biosphere reserves, one each from the Pacific, Arctic and Atlantic coasts, are also to be considered. At the same time, opportunities to add biosphere reserves from the more "southern" parts of Canada should be taken up, especially if they could exemplify the concept being applied in practice under quite different ecological and organizational settings, and they have a good basis for developing the different functions of biosphere reserves. Two candidates now being pursued, Charlevoix in Quebec and Algonquin-Petawawa in Ontario, are examples.

Cooperation With Other MAB Groups

Canada/MAB works informally with other MAB groups in several different ways. We have participated in two "panel reviews" convened by US/MAB to discuss candidate sites for biosphere reserves in the Lake Forest Biogeographic Province (extending across the lower Great Lakes to the east coast) and in the Acadian-Boreal coastal region (extending from Cape Cod to the Gulf of St. Lawrence). From time to time, we have also discussed possibilities for other transboundary biosphere reserves, similar to Waterton-Glacier; some potential for these exists along the Alaska-Yukon boundary centering on the new Northern Yukon National Park and surrounding areas, in the Quetico-Superior area of Minnesota and Ontario, and in the Lake Champlain-Richelieu River basin of New York, Vermont and Quebec. The two national MAB committees for the first time held a joint meeting in Ottawa in December 1986.

Other informal cooperation has been maintained through meetings of the UNESCO Scientific Advisory Panel on Biosphere Reserves, which met twice in 1985 and 1986, through "regional" (in the U.N. sense) MAB meetings held in Czechoslovakia in 1986 and the Federal Republic of Germany in 1987, and through the UNESCO "Northern Science Network". The latter was created in 1982 to foster cooperation among the circumpolar countries, but experience from its first five years suggests that a somewhat more formal arrangement will be required to develop this effectively.

For the Future

The ideals of MAB and of biosphere reserves as centers for addressing interrelated environmental, resource use, and socio-economic problems are even more crucial for the issues of today, than some 15 years ago when they were first formulated. The World Conservation Strategy and report of the Brundtland Commission (World Commission on Environment and Development) have emphasized the urgency of a transformation to strategies for ecologically sustainable development. Applied research to gain the knowledge needed to do this, in the vast array of different ecological, socio-economic and cultural circumstances found throughout the world, is vital. Biosphere reserves are the kinds of places where this work can best be done.

This does not mean that all protected areas must somehow be transformed into biosphere reserves. It does mean, however, that biosphere reserves must become a more widely used component of the range of institutional arrangements for the protection and selected uses of different landscapes and "seascapes," a range that must also include strictly protected wilderness areas.

To bring this about, the global "Action Plan for Biosphere Reserves" must be pursued. The global network must be completed, the diverse functions of biosphere reserves must be developed (otherwise the purpose or significance of a MAB designation on long established parks and equivalent areas will be called into question), and the work done in them must be guided by the ideal of demonstrating, in local and practical terms, some ways to achieve sustainable resource use practices. First priority must go to developing a few fully-functioning biosphere reserves to serve as good working models of the potentials inherent in the concept. In North America, we should become leaders in this endeavor.

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CASE STUDY: WATERTON BIOSPHERE RESERVE

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ABSTRACT. Waterton Lakes National Park (Canada) was designated a biosphere reserve without the benefit of direction for an applicable program. The paper describes the gradual development of Waterton's program which involved the establishment of a management committee chaired by local ranchers and an advisory technical committee. The functioning of Waterton and Glacier National Park (United States) as components of an international peace park is also discussed.

KEY WORDS: Waterton Lakes National Park, Glacier National Park, biosphere reserves, zone of cooperation, local involvement, international cooperation, international peace park.

Waterton Lakes National Park and its Neighbours

Waterton Lakes National Park is located in the extreme southwest corner of the Province of Alberta, Canada, bounded by the Continental Divide and the Province of British Columbia to the west and Glacier National Park in the State of Montana (USA) to the south. The 525 km^2 park, which was established in 1895, protects a representative area of the Rocky Mountains, specifically the Border Ranges and adjacent fescue grassland. The park's most distinctive feature is its abrupt transition from mountains to rolling prairie without any exposed intervening foothills.

Waterton and its 4144 km^2 neighbour, Glacier, were designated in 1932 as the world's first international peace park. The two parks have many cooperative programs. They exchange interpretive staff, co-host public and special events (i.e., the International Seminar). They hold joint staff meetings to share information and to plan new initiatives. The parks use a single visitor brochure and each provides visitors with daily information on weather and trail conditions in its sister park. The parks have mutual aid agreements for search and rescue and fire fighting. They also use the same back country signage, and Glacier provides trail distances in metric measures as Waterton is required to do. There is cooperative resource management and occasional joint patrols in the back country. The staff in each park, although dressed in their respective uniforms, wear a common badge signifying the International Peace Park. Finally, the two Superintendents address issues together which affect the International Peace Park.

Waterton, unlike Glacier, has many private land holdings on its boundaries. The land is generally used for ranching purposes and this results in very scenic approaches to the park. The size of many of the ranches is in excess of 500 ha (2 sections); their owners are concerned about long term productivity of the land, the economic viability of their operations, and maintenance of their quality of life. Friction between the park and private ranches has largely been related to crop and hay bale depredations by what are considered to be "park elk." Some ranchers are also concerned that the presence of the park is changing land use in the area, from ranching to the provision of visitor facilities.

In recent years, approvals have been given for a multimillion-dollar water theme park on the park's northern boundary and for a small cottage subdivision and commercial development on its eastern boundary. Such proposals can result in public hearings and strong debate in the two municipal districts involved. The park and some ranchers have found themselves arguing against particular developments. Other ranchers and small land owners have resented the fact that the park Superintendent will speak to issues outside the park. The business community inside the park may also be split over a development issue immediately outside the park, some seeing it as potentially taking away business, others viewing it as an additional attraction to hold visitors in the area.

One of the most difficult issues facing the park and some of its rancher neighbours involves the predation by grizzly bears on cattle in a 14.4 sq. km provincial grazing reserve. The heavily grazed but well forested reserve is situated on Waterton's eastern boundary and Glacier's northern boundary. It also is on the northern boundary of Blackfeet Indian tribal lands in Montana.

Members of the grazing association who use the reserve claim that more than 80 of their cattle have been killed by bears in the past five years. Evidence shows that there have been cattle losses caused by bears, and 4 grizzly bears were removed by Provincial Wildlife officers in 1986. But the problem has continued in 1987 and 3 more bears have been removed. The Province of Alberta is partly compensating ranchers for losses. Some ranchers want more compensation and authority to shoot bears on sight. They also want bear control measures taken in the Peace Park. Parkand Provincial staff lack basic information on bear dynamics and on other factors which may be responsible for cattle losses. The issue is a perfect one to deal with through the biosphere reserve program. An initial meeting attended by members of the grazing association, staff from the Park and Province, and politicians has been held. The Management Committee plans to follow up to encourage a coordinated approach to the problem.

There are several sour gas fields around the park and one of them is the largest in Canada. Wells have been drilled within 100 m of the park boundary. Shell Canada requested permission to do seismic work in the park, which was denied, and to use the park boundary cut line for access to areas outside the park, which was approved to decrease overall impact on adjacent privately-owned lands. The park has in the past had poor communications with Shell Canada and has regarded the company as a threat to natural resource protection. Many local ranchers also object to the gas field operations which include a large reduction plant, while others obtain employment from the company. In the past few years, meetings have been held, initially at the instigation of the Biosphere Reserve Management Committee, to discuss problems involving local ranchers, the park and Shell. Now Shell Canada invites its neighbours to meetings to discuss new development proposals.

The Provinces of Alberta and British Columbia have forests adjacent to the west and northwest of Waterton. These forests were attacked by the mountain pine beetle in the mid-1970s, which resulted in clearcut salvage logging operations to control its spread. The clearcuts are very visible from certain higher elevation trails in Waterton. These areas, which were used for wildland recreation and are accessible from Waterton, are no longer attractive. Conservation groups have lobbied for their inclusion in Waterton Lakes National Park or for some other protective status. Provincial governments view the lands for their multiple use value, including mining and future logging, but are aware of the concern many people have to begin protecting areas adjacent to the national park. The Province of British Columbia recently provided some degree of protection to an area bordering Waterton and Glacier by designating it as a Provincial Recreation Area.

An outlying "timber limit" for the largest Indian Reserve in Canada was at one time surrounded by the park as a result of 19.4 km^2 of park lands being transferred to the Blood Indian Band. Now with a land exchange it is surrounded on three sides by the park. Relationships between the park and Band have been, for the most part, strained as a result of boundary issues, poaching, and livestock straying into the park. Recent attempts to work with Band members at the nonpolitical level to provide interpetive events have been successful. (See *National Geographic*, June 1987 issue, "Waterton-Glacier: Pride of Two Nations," for a discussion of the Peace Park and the boundary issues.)

Waterton Biosphere Reserve

Its Organization

In 1979 Waterton was designated as a biosphere reserve in response to Glacier National Park having been so designated in 1976. The two biosphere reserves have individual but linked programs. Waterton's program concentrates on local issues and local involvement in addressing them. Glacier's program is more oriented towards research.

The early history of Waterton's program is well documented (Cowley and Lieff 1984, Lieff 1985a, Lieff 1985b). Briefly, it began two years after the biosphere reserve was so designated and at the previous park superintendent's initiative to explore what the concept meant. A meeting including local people, park staff and researchers was held to discuss a possible program, but it was very evident at the meeting that the biosphere reserve concept was difficult to grasp in practical terms. This was partly overcome months later by the incoming Superintendent attending a conference in 1981 which reviewed the 10-year history of MAB. He arrived on the scene with a good appreciation of what the designation was intended to promote. The following year, through the efforts of Environment Canada Parks and the United States' National Park Service, a symposium was held near the Peace Park to explore "relationships between parks and adjacent lands" (Scace and Martinka 1983). This meeting, attended by people representing industry, conservation groups, universities, federal, provincial, state, municipal governments, and the ranching community, was a catalyst for the local program.

A Biosphere Reserve Management Committee consisting of park staff and ranchers was formed in 1982. It is chaired by two local ranchers who are very active in their respective communities and view the park very positively. The Committee invited federal and Provincial agencies with resource management jurisdictions in areas surrounding the park to join a technical committee. Glacier National Park also has a representative on it. Each committee prepared its own terms of reference relating to a statement of purpose developed by the Management Committee based on literature it had received from the Canada/MAB Working Group on Biosphere Reserves. The Technical Committee advises the Management Committee on research, design and monitoring programs. It reviews research proposals and reports arising from research in the biosphere reserve. It also provides educational and training opportunities through projects its members carry out in the biosphere reserve. The Committee has held field days for local people to view research in progress.

Through the involvement of a number of agencies in the Technical Committee and local participation, the Biosphere Reserve has unofficially extended itself beyond the "core" or park area. It now has a "zone of cooperation" extending out on private and government lands about 25 km from the park. There is no document recognizing this zone; its existence is simply a local understanding among those who cooperate with the Management Committee. Since the Management Committee is dominated by local ranchers as opposed to park staff, it is less threatening than might otherwise be the case and this encourages local cooperation. The ranchers involved are committed to make the concept work. They involve other ranchers in determining issues the Management Committee should address. Anyone may attend a Management Committee meeting. Although this is a fairly unstructured arrangement, what is important is that it works for our local circumstances.

Funding

For the first four years of the program, seed funding provided by Environment Canada Parks was controlled through the financial office for Waterton Lakes National Park. This money was used to host public meetings, pay some expenses of members to attend meetings, and cover administrative costs. With all the volunteer assistance the program ran on about $2,000 Cdn/year. Now that the program is well established and fiscal responsibility has been demonstrated, the funding is directed through Canada MAB directly to the Treasurer of the Management Committee.

Capital funds and services have been raised through soliciting governments and the private sector in the area. At this point there has been no attempt to raise a large sum to fund research projects; rather, the research agencies have been approached to direct some of their efforts to problems in the biosphere reserve. The two committees have produced inexpensive brochures which describe the organization and summarize the program, including all current research efforts. The pamphlet has been very useful in soliciting assistance, as it shows that a successful program exists and explains its purpose.

The Public Program

Initially the program was based on public seminars dealing with issues of local concern but not of a highly emotional nature. The Management Committee brought together those who had a problem with those who might have a solution to it.

The research initiatives developed out of these public sessions to address problems for which there were no obvious answers.

An educational thrust was added through the field days sponsored by the Technical Committee and by members of the Management Committee visiting public schools, technical colleges and universities to talk about the biosphere reserve program and how it was being implemented in Waterton and elsewhere in the world.

As the biosphere reserve concept became more understood locally, the Management Committee addressed some controversial issues. Seminars have been held on bear management, game ranching and sale of provincial public lands. The purpose of the seminars is to make people aware of issues that may affect the reserve area and to suggest how they may make their views known. The Committee is careful not to become another environmental lobby, although there are those who see its usefulness in this area. In fact, the Committee continually reminds people of the biosphere reserve concept: demonstrating the value of integrating conservation with development. The Management Committee has become a focus for local input into land use decisions in the Waterton area. It is invited to review documents, attend meetings and make representations to responsible authorities. It also has functioned as a facilitating body in identifying concerns and resolving problems between the natural gas industry and the ranching community.

Some Recent Initiatives

A brush control project is an example of a research project designed by an Alberta Provincial member of the Technical Committee and involving local ranchers. This demonstration is designed to compare the success of brush control and forage species establishment with maximum versus minimum tillage techniques. Initial results have been shown to ranchers through field inspections.

Figure 1: Pine Ridge viewpoint, a popular roadside stop in the Zone of Cooperation. Plaques explain the Biosphere Reserve and Peace Park programs.

Recognizing the need to tell visitors as well as local people about programs involving the park, the Management Committee has developed an interpretive view point on one of the highways leading to the park (Figure 1). The view point was constructed on a sweeping bend of the highway, where visitors often stopped on the shoulder to take photos of the rolling ranchlands with the mountains of the two national parks and forest preserves in the background. One panel interprets the Peace Park, a second the Biosphere Reserve and local involvement in it, while the third is a photo of the area with names shown of mountain peaks and valleys along with several messages about the natural and human history of the Waterton area. Reference is made to land uses such as ranching, gas extraction and tourism attractions.

The Province of Alberta provided the land for the view point and prepared the site. Shell Canada Resources Ltd. contributed half of the funds required. Several ranchers helped develop the text for each panel. The Parks Regional office staff did the graphics and supervised the contract for production of the panels. The logos of sponsors and of MAB were placed on one of the panels. On July 1, Canada Day, 1987, a ceremony was held to unveil the exhibit, followed by a barbeque. All local ranchers were invited and almost all attended. They were addressed by representatives of all project sponsors, as well as representatives of the two municipal governments around Waterton. This very successful project has encouraged the Committee to look at a similar project in the adjacent municipality.

The Annual Superintendents' International Peace Park Hike has been an effective means of making friends for the two parks and bringing together development and conservation interests. Begun in 1985 to celebrate the 75th Anniversary of Glacier National Park and the 100th anniversary of the National Parks of Canada, the invitational hike is a simple way of extending the biosphere reserve concept. Each superintendent invites representatives from local industries and businesses, conservation groups, universities, the media, politicians and their appointed staff, and local residents (ranchers and cottage leaseholders in the case of Waterton) to experienoe the Peace Park in a three-day hike. Participants are required to pay their own way, but tents are provided as is mule transportation for all equipment. At the end of the hike, a new host of friendships have been made among people who might have regarded some of the participants as being an adversary.

The hike ends with a supper at which time participants discuss what they got out of it. Many useful ideas have come from participants. One example is the United States/ Canada Days of Peace and Friendship, which is now an event approved by both American and Canadian governments, to be celebrated on July 2 and 3, linking July 1, Canada Day, to July 4, Independence Day in United States. Just as importantly, the communication network for the two parks has expanded into key additional areas through the contacts made.

Expanding the Network

Waterton Biosphere Reserve's progress in becoming fully operational in terms of the Action Plan for Biosphere Reserves has been gradual, sometimes painfully slow in the view of Committee members. However, Waterton appears to be one of few examples of an early long-term effort having been made in North America.

As a result of this modest success, Committee members have been invited to share their experiences with others who have been considering biosphere reserve status. They have met with local people and representatives of governments in areas where biosphere reserves were later established, including Riding Mountain Biosphere Reserve in Manitoba and Long Point Biosphere Reserve in Ontario. They also met with a group looking at a similar status for Voyageurs National Park in Minnesota, where the recommendation was not to establish one. The Waterton experience was related in a meeting of American biosphere reserve managers held in 1984, being used as an example of a protected area expanding its area of influence beyond its boundaries through involvement of local people in the program.

Information has been provided to Australia (Fitzgerald Biosphere Reserve), China and Peru for teaching purposes. In 1986, the Management Committee was successful in its application to Canada/MAB for funding to assist in activating the Northwest Biosphere Reserve in Peru. One of our Management Committee members, Dr. N. Simons, who was going to Peru, used the opportunity to work with the staff of the National Agrarian University near Lima in developing an action plan. The staff involved is using the funding in coordination with a World Wildlife project to hold local meetings. The intention is to explain the functions of a biosphere reserve and set up a committee of local land users, government officials and others to assist in managing the area.

In the fall of 1987, Committee members had the opportunity to discuss their program with delegations from Nepal and China.

The key factor to successful dialogue with non-government representatives has been the local people telling of their involvement in the program.

Some Things We Have Learned

The Management Committee should have involved local politicians, industry representatives and park leaseholders from the beginning to encourage wider-spread acceptance of the program. Now advisors from these first two interest groups work with the Committee, and a cottage leaseholder has become a member.

The media must be given a clear understanding of the program so that it is properly portrayed to the public. The brochure developed by the Management and Technical Committees really helped in this regard.

Acceptance of the programs by local people and by various governmental institutions may occur very slowly. The high profile of a few well accepted non-government people will help erase fears of this being "another government plot to control . . ."

The manager(s) of a designated area must have an open management policy encouraging others to become involved while understanding and respecting the limits involved in shared decision-making. This applies to other cooperators as well. The author found it difficult initially to involve local people for fear of "losing control."

It is important to involve students at all levels; they can become very strong supporters and influence others to be likewise.

The program committee members must eventually deal with oontroversial issues. In doing so, they should remember the mission statement for biosphere reserves. They must discourage the use of the designation for lobbying purposes against conservation or development issues, while encouraging rational discussion of projects and their social and environmental implications.

Our Technical Committee has representatives from various federal and provincial agencies with differing mandates. This can make it difficult for the Committee to have a focused approach and for members to fully participate. Initially, the Management Committee did not provide sufficient direction to the Technical Committee nor did it keep itself involved with it, which decreased the enthusiasm of the Technical Committee. It is important that various committees which may be set up have terms of reference and the linkages between the committees are described.

Conclusion

The Waterton Biosphere Reserve Program is but one example of many. It may be applicable in other situations to various degrees. The committees are still striving to improve the program, especially in the areas of education and research. They have learned that progress can be gradual in spite of a lot of commitment by individuals. The committees would be pleased to provide additional information to readers.

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THE SOUTHERN APPALACHIAN MAN AND BIOSPHERE COOPERATIVE PROGRAM

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ABSTRACT. The Southern Appalachian region has been chosen for the development of a prototype action program for the Man and the Biosphere (MAB) program in North America. The existing biosphere reserves of the area, Coweeta Hydrologic Laboratory and Great Smoky Mountains National Park, are described, along with the Oak Ridge National Environmental Research Park, which has been nominated for biosphere reserve status. The history of MAB programs in the region is discussed, along with plans for the future, which include the establishment of a coordinating organization consisting of agencies and institutions dedicated to the establishment of collaborative efforts associated with the MAB program.

KEY WORDS: Man and Biosphere, biosphere reserve, conservation, regional cooperation, Southern Applachians.

Description of Region

The ancient Appalachian Mountain Range in the eastern United States extends from Maine to Georgia, achieving its greatest elevation in the Southeast due to a massive uplift created by the collision of continental plates along a zone which now includes the Carolinas in the United States and the northeastern coast of Africa. The Southern Applachians form the boundaries of seven states (Figure 1). Due to the rugged topography, the mountainous region is relatively sparsely populated. A large percentage remains in public ownership. In fact, it represents one of the largest blocks of contiguously held public lands east of the Rocky Mountains.

The region is rich in cultural heritage unique to the Appalachian highlands. The native American nation of the Cherokees have a reservation in the heart of the reserve. European settlers in these regions lived somewhat isolated lives. The area remains a center of mountain crafts and music and retains many examples of early 19th century buildings. Today, people come from all over the country to experience this cultural heritage and take home examples of basketry, woodcarving, weaving, and numerous other handicrafts.

The region is also a center of higher education and research, much of which involves natural resources. The three sector biosphere reserves discussed in this paper are centers for such research and education, as are the Natural Resources Institute at North Carolina State University in Raleigh, the Institute of Ecology at the University of Georgia in

Athens, the Graduate Program in Ecology at the University of Tennessee in Knoxville, and the U.S. Forest Service Forest Experiment Station in Asheville, North Carolina.

During the early 1980s, the U.S. national economy and population growth shifted to the southern tier of states. This growth has been felt in the Southern Appalachian region, particularly in terms of commercial and residential development associated with tourism and vacation housing. In Pigeon Forge, for instance, which is seven miles from the entrance to the Great Smoky Mountains National Park Biosphere Reserve (GSMNPBR), the number of motel rooms has increased from 4,000 in 1983 to 12,000 in 1987. The gross annual revenues of that single tourist community increased from $114 million in 1985 to $210 million in 1987.

This tremendous growth occurs in a region with minimal land use controls. There are few zoning laws in most parts of the region, and the ones in place are not well enforced. As a result, high rates of stream siltation are common, steep slopes and ridgetops are used inappropriately as building sites, and waste treatment is often unsatisfactory. As these areas grow, the availability of local water supplies is becoming less certain. Many of the water reservoirs in the region are highly polluted with wastes from industrial and municipal sources.

Other environmental problems include various exotic species threatening native populations, and exotic insect infestations such as the balsam woolly adelgid, which kills mature Fraser fir (*Abies fraseri*), and the oak-defoliator gypsy moth (*Lymantria dispar* [L.]), which defoliates deciduous hardwoods. Air pollution is also a pervasive problem, particularly in the high elevation forests.

To counter these various environmentally-based problems in the region, an unusually large number of programs are underway under the auspices of various public agencies and research institutions. The Man and Biosphere Program is being suggested as a framework for the various public agencies and research institutions to channel their divergent energies toward developing the knowledge and skills to effectively address these conflicts between man and nature. The goal is to provide the basis for sustained economic development while maintaining a high standard of environmental quality.

This potential has been recognized by a UNESCO-MAB committee selecting areas suitable for the development of prototype action plans for biosphere reserves. The Southern Applachians has been selected as a suitable site for the development of a prototype action plan for North America.

Existing Biosphere Reserve Units

At present, there are three biosphere reserve units in the Southern Appalachians.

Great Smoky Mountains National Park Biosphere Reserve (GSMNPBR)

Great Smoky Mountains National Park was established "for the benefit and enjoyment of the people." This purpose was stated by Congress in the act of May 22, 1926, that provided for establishment of the park. That act further defined the purpose by reference to the National Park Service Organic Act of August 25, 1916, which stated that the fundamental purpose of national parks is "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (National Park Service 1982).

The park is distinguished by the extraordinary diversity and abundance of its plants and animals, the beauty of its mountain terrain and waterways, the quality of its remnants of pioneer culture, and the sanctuary it affords for those resources and for its modern human users. The purpose of the park is to preserve these exceptionally diverse resources and to provide for public benefit from and enjoyment of them in ways that will leave the resources--and the dynamic natural processes of which they are components--essentially unaltered. Some benefits and pleasures available to visitors because of park programs are increased knowledge of the natural environment and cultural history, aesthetic gratification, and opportunities for rewarding activities that will not seriously impair the resources. International recognition of these natural and cultural resources occurred with the park's designation as a biosphere reserve in 1976 and world heritage site in 1984.

Included within the states of Tennessee and North Carolina, the park is roughly an elliptical area of 209,000 ha and is of sufficient size to provide self-perpetuating biological opportunities. The park ranges in elevation from 260 m above sea level to 2,025 m, including 16 peaks above 1,800 m, and contains 22 major watersheds, 33 clear mountain streams totaling 1,180 km, 123 individual brook trout waters, 10 major waterfalls, lesser falls and cascades that have never been enumerated, and 668 km of foot trails through landscapes and habitats of uninterrupted natural beauty.

The area once included the major North American refuge for the preglacial warm temperate and temperate zone flora during the Pleistocene glaciation and thus has one of the nation's richest inventories of such plant groups as fungi, mosses, lichens, and hepatics. The park has a high floristic diversity (about 1,450 species of flowering herbaceous plants; 2,200 other plant species) characteristic of the temperate broadleaf forest biome, with large numbers of species occurring in the same stands. Comparable floristic diversity in this bbiome is found today only in restricted areas of Eastern China. The park exhibits almost as many kinds of native tree species (130 species) as in all of Europe. One of its major forest types, the Cove Forest, has 25 to 30 tree species, with 6 to 12 dominant on any one site. A one-tenth hectare plot may support 40 to 50 species of herbs through the seasons. The list of endangered plants that occur within the park includes 120 species. There are large expanses of virgin forest, perhaps totaling about 8,000 ha--a precise figure is impossible because some areas were logged so selectively and long enough ago that it is difficult to be sure how much was never logged.

Interpretation of the natural and cultural resources of the park is carried out by a variety of means: maps, publications, and three "living history" areas for demonstrating cultural traditions.

The best testimony of the public appeal for the park is the fact that Great Smoky Mountains received over 10 million visits in 1987, the most popular park in the U.S. National Park System.

The GSMNPBR has long been a focus of scientific study. Since 1975 the Uplands Field Research Laboratory has been stationed at the biosphere reserve as a focal point for research activity. In 1985 a complementary office was established at the neighboring

University of Tennessee. An annual science meeting is held each spring among scientists working in the park. Scientists at the Uplands Laboratory have been the primary contributors to a Research/Resources Management Report Series published by the Southeast Regional Office of the National Park Service in Atlanta.

Coweeta Hydrologic Laboratory Biosphere Reserve (CHLBR)

The site was set aside as the Coweeta Experimental Forest in 1934 and almost immediately, measurements of rainfall, streamflow, climate, and forest growth began. There has been continuous monitoring since. The first laboratory buildings, roads, climatic stations, and stream measurement devices were built in the 1930s. In 1948, the site was renamed Coweeta Hydrologic Laboratory, the only Forest Service outdoor site to carry the "Laboratory" title. As activities at Coweeta increased, new office space and a new laboratory for chemical analysis were added. Computer storage of data, begun in 1958, has been pivotal in analyzing the long-term records compiled here.

More recently, the Laboratory was selected by the National Science Foundation as one of the original sites for the Long-Term Ecological Research (LTER) program. The Laboratory's commitment to sharing its research with scientists worldwide has been recognized by its inclusion in the International Biological Program, the International Hydrologic Decade, and UNESCO's international network of biosphere reserves.

In addition, Coweeta Hydrologic Laboratory has assumed an important role in the training of new scientists in many biological fields. Scientists and graduate students from many institutions and other government agencies conduct research projects here in cooperation with staff scientists (USDA Forest Service 1984).

After establishment of the site in 1934, the period of the 1930s was dedicated to calibration of the hydrology of the watersheds on the 2,185-ha site. A network of 56 standard rain gauges and numerous weirs and groundwater wells were established for the calibration process.

By 1940, calibration of watersheds at Coweeta was far enough along on some catchments to begin treatments, and a period of experimentation began. Since 1940, a variety of watershed experiments have been conducted at Coweeta. The harmful effects on soil and water resources of mountain farming, woodland grazing, and unrestricted logging were documented in early studies. These early land use demonstrations were publicized in the highly successful film, "Waters of Coweeta." Water yield experiments designed to measure effects on streamflow of complete or partial forest cuttings and conversion from one type of cover to another have provided conclusive evidence that water yield is influenced by the type and characteristics of the vegetative cover. The knowledge gained in these early experiments was the basis for a pilot test of intensive multi-resource management of Southern Appalachian forests and has provided guidelines for watershed management on public and private lands alike. More recent experiments using cable logging methods and advanced forest road designs have demonstrated improved methods for managing steep mountain lands to minimize damage to soil and water.

Coweeta research in the late 1950s explored the effects of soil-plant-atmosphere interactions on hydrological processes. By 1970, substantial progress had been made in water yield investigations, and emphasis shifted from water quantity to water quality, including research on nonpoint-source pollution and the use of herbicides in management. At the same time, a major cooperative program of research on biogeochemical cycling in forest ecosystems was initiated with the Institute of Ecology at the University of Georgia. Funded by the National Science Foundation, this cooperative project became part of the Eastern Deciduous Forest Biome of the International Biological Program. Studies have focused on the responses of forested watersheds to various kinds of disturbances. A background of 16 years of ecosystem research supported by 50 years of hydrologic research at Coweeta enables an interdisciplinary team of federal/university scientists to participate effectively in the NSF-sponsored Long-Term Ecological Research program and the biosphere reserve program of UNESCO (Gaskin et al. 1983).

In 1984, Coweeta Hydrologic Laboratory commemorated 50 years of scientific activity with a conference in Atlanta. The proceedings of that conference provide an excellent overview of research conducted.

Oak Ridge National Environmental Research Park (ORNERP)

The Oak Ridge National Environmental Research Park, designated as a biosphere reserve unit in 1988, is located at Oak Ridge, Tennessee, on the U.S. Department of Energy's Oak Ridge Reservation west of Knoxville. The city of Oak Ridge borders the site on the north. The Tennessee Valley Authority's Melton Hill and Watts Bar Reservoirs on the Clinch River form southern, eastern, and western boundaries. The Cumberland Mountains are about 16 km northwest and 113 km to the southeast of the Great Smoky Mountains. The unit represents approximately a third of the Oak Ridge Reservation, which was established in 1941, from land that was mostly agricultural, as part of the U. S. Army's Manhattan Project. It presently consists of 14,433 ha of federal land.

The ORNERP was established on June 5, 1980, and consists of 5,008 ha on the Oak Ridge Reservation. Areas representative of the region have been designated ORNERP Reference Areas. Experimental environmental research (both manipulative and non-manipulative) has been done at various locations on the site since the mid-1950s. Land uses on the Reservation include forestry, security, waste management, wildlife, site development, resource characterization, and environmental monitoring and research through the National Laboratory's Environmental Sciences Division, much of it conducted at ORNERP.

The ORNERP is within the Ridge and Valley province of the Southern Appalachians and is characterized by parallel southwest-northeast oriented ridges of sandstone, shale, and cherty dolomite separated by valleys underlain by less weather-resistant limestone and shale. The area includes gently sloping valleys, rolling to steep slopes and ridges. The topography results from differential erosion of severely folded and faulted rocks ranging in age from Early Cambrian to Early Mississippian. Soils developed from the weathered geologic substrate are members of the ultisol group, which includes the red and yellow podzolic soils.

Plant communities are characteristic of those found in the intermountain regions of Central and Southern Appalachia. The principal biome is the temperate broadleaf forest, with the oak/hickory association dominant. Other important communities include natural yellow pine forests, eastern red cedar barrens, bottomland hardwood forests, northern hardwood forests, loblolly pine plantations, old fields and grasslands, and streams and rivers. Approximately 900 vascular plant species have been documented. Eleven state-listed rare plant species occur in 18 locations.

The diversity of vegetation creates favorable habitats for a wide variety of animal species typical of the region. Approximately 315 different vertebrate species have been recorded for the ORNERP, with 52 fish species, 24 amphibian, 32 reptilian, 168 avian, and 39 mammalian species. There are a few state-listed rare animal species.

The Oak Ridge Reservation is designated a Wildlife Management Area and is managed by the Tennessee Wildlife Resources Agency, which employs an on-site manager.

The following three distinct types of areas are designated at ORNERP:

1. Reference areas - sites that are representative of the region or contain unique biotic features; can be used for nonmanipulative environmental research; important for baseline information.

2. Natural areas - sites designated by the Department of Energy where rare plant populations occur; used primarily for nonmanipulative environmental research but may also involve active habitat management for related species. Some sites are registered as state natural areas and have a protective agreement between the Tennessee Department of Conservation and the Department of Energy.

3. Research areas - areas used for manipulative research.

Field research on the Oak Ridge Reservation began in the mid-1950s with radionuclide investigations, then moved into IBP production studies and biogeochemical cycling research (Walker Branch watershed). Present areas of research include biogeochemical cycling, biomonitoring, ecosystem dynamics, toxicology and ecological effects, environmental engineering, environmental and soil chemistry, geology and geochemistry, hydrology, physiological ecology, and biomass production. Future directions will continue to emphasize biomass/biogeochemical research (watershed and global). Research in the ORNERP has resulted in approximately 200 publications.

Routine environmental monitoring for compliance with state and federal licenses is done on the site through the Environmental and Occupational Safety Division. The Environmental Sciences Division is responsible for biological monitoring and abatement programs for the major creeks on the site.

Cooperative Projects Sponsored by MAB

The GSMNPBR has been the fortunate recipient of considerable leadership from the MAB-8 directorate over the last decade, resulting in the completion of several significant projects:

<u>A history and bibliography of scientific studies at GSMNPBR</u>. The primary purpose of this project was to provide a basic reference on the history of scientific activities and the

current available information base at the GSMNBPR. It was designed to (1) assist in the evaluation of the park's science program by the National Park Service and outside authorities, (2) serve as a review document for planning future science program development, and (3) serve as a current source of general information for resource managers, planners, and scientists concerned with the Reserve's ecosystems and the influence of human activities upon them. To the extent possible, an attempt was made to provide a prototype MAB document for presenting information relevant to science program formulation and evaluation in International Biosphere Reserves (McCrone et al. 1982).

Ethnobiology project. From 1983 to 1985, Tennessee State University conducted a survey of the ethnobiology of the Southern Appalachians. Results of the study indicate that:

1. At least 60 percent of the region's plants had some kind of cultural use, ranging from foods to medicines, dyes, inks, fibers, craft and building materials, bee plants, chewing gum, oils, syrups, flavorings, candies, shaving lotions, soaps, perfumes, and miscellaneous chemicals. There were even insecticides and repellents and a plant used to stun fish for easy capture.

2. Many species had more than one use.

3. There were 977 different species that had some kind of medicinal use.

4. Native Americans used over 800 plants for medicines, while settlers had 200 to 300 separate species in natural remedies.

5. Even today, 129 species from the Southern Appalachians are known to be used in the pharmaceutical trade.

Natural dynamics of forested ecosystems. The objective of this research effort, conducted in 1981 and 1982, was to investigate biological processes important in regulating the nitrogen cycle of forest ecosystems. Specific objectives were to quantify rates of nitrogen fixation, nitrification activity, mineralization, and denitrification in litter and soil compartments of undisturbed and disturbed forest ecosystems in GSMNPBR. The disturbed forests were high-elevation forests which are repeatedly rooted by European wild boar and successional forests in areas logged prior to establishment of the park.

Island biogeography. This 3-year study evaluated species abundance and distribution inside and outside the park. Vegetation plots and small mammal surveys were the principal means of assessment.

Remote sensing. In 1982, MAB helped purchase low-elevation flights over the park using a LANDSAT platform to acquire high resolution imagery. This project inspired a 6-year project to map forest types based on remote sensing data. The resulting reflectance data set, along with a host of other digitized themes, will serve as a primary tool toward the establishment of a landscape scale long-term monitoring program.

Environmental education. Funded by the City of Gatlinburg, Tennessee, a graduate student, Kimberly Tassier, from Ohio State University has developed a series of school lesson plans for grades 1 through 8 which address the MAB program and various resource issues, such as air pollution; exotic species; selected native species requiring private sector stewardship, such as black bear; and overall stewardship of the landscape. Upon completion, these lesson plans will be distributed to 150 primary schools in the Southern Appalachian region surrounding the park.

Exhibit. An elaborate back-lit display was developed concerning the social values associated with sustaining biodiversity with examples specific to GSMNPBR.

MAB community relations strategy. The purpose of the project was to outline a strategy in a simplified form to systematically initiate community-based MAB programming. Principles of communications planning are used as a framework for developing that programming strategy. The strategy recognized that long-term commitments to specific community programs are the building blocks of community support and their involvement in management activities, which in turn are important factors in the full realization of the MAB program (Peine et al. 1988).

Conference on the management of biosphere reserves. The GSMNPBR hosted a conference for the managers of biosphere reserves on November 27-29, 1984. Cosponsors included the UNESCO-MAB Secretariat, the Canadian National Committee for Man and Biosphere, the U.S. National Committee for Man and Biosphere, the National Parks and Conservation Association, the U.S. National Park Service, the USDA Forest Service, and the Southern Appalachian Research and Resource Management Cooperative. A large number of biosphere reserve managers met to discuss the multiple roles of biosphere reserves. Prior to this meeting, the biosphere reserve program had emerged primarily as a scientific initiative; it was time to bring the full spectrum of the program to the attention of the managers of designated areas.

In general, the managers who came to the conference were unfamiliar with the objectives of the biosphere reserve program. The conference sought to address their expressed confusion about the intent and opportunities associated with biosphere reserves. The conference attracted a wide range of participants. Along with representatives from 27 biosphere reserves in North America and six foreign countries, a variety of other interested groups were represented. These included nonprofit conservation groups, legislative specialists, teachers, scientists, news media, and a few private citizens participating in biosphere reserve programs. This mixture of divergent perspectives nourished a productive dialogue (Peine 1985) and enhanced the awareness of MAB and the biosphere reserve program among its potential advocates and interested administrators.

MAB video program. A local public television station interviewed attendees of the MAB conference and produced a 20-minute program on the MAB initiative.

Park staff training on MAB. Employees of the GSMNPBR were given an orientation to the MAB program.

Strategy for Cooperation

In order to facilitate the cooperation among existing and proposed biosphere reserves in the Southern Appalachians and expand the scope of programs to be representative of true regional perspective, an interagency agreement recently has been signed to establish the Southern Appalachian Man and Biosphere (SAMAB) Cooperative. Member institutions include the U.S. Department of the Interior (National Park Service and U.S. Fish and Wildlife Service); the U.S. Department of Agriculture (USDA Forest Service; Southern Region, National Forest Systems; and Southeastern Forest Experiment Station); Tennessee Valley Authority; and the Economic Development Administration. The U.S. Department of Energy is expected to join the consortium soon. The cooperative represents several land management and planning agencies with interests in the general area of the Southern Appalachian Mountains. All parties to this agreement are joining in a common effort to promote the wise use of the area's renewable resources, to increase environmental awareness to the general public, to encourage environmentally compatible economic development, to promote a prideful awareness of the special nature of the internationally significant Southern Appalachian region among its residents, to support and encourage continuing research helpful to the maintenance and understanding of the region's resources, and to embark upon a process which ensures the sharing and circulation of the results of regional research efforts (Southern Appalachian Man and Biosphere Cooperative 1988).

The interagency agreement may be used to pool funds and human resources to enter into a cooperative project. A proposal to establish a SAMAB Coordinating Office and a SAMAB Foundation are under consideration.

Eventually, additional units may be nominated to the Southern Appalachian cluster of biosphere reserves, such as selected wilderness areas managed by the Forest Service, selected state parks, natural areas designated by the states, and private natural areas such as Grandfather Mountain in North Carolina.

Focus for the Future

A variety of topics are being considered for emphasis in future projects:

<u>Environmental education</u>. A substantial number of excellent environmental education programs are ongoing in the region. Both GSMNPBR and ORNERP, for instance, have well targeted programs. Minimal effort would be required to provide a clearinghouse of materials, ideas, and opportunities for integrating activities in the region into a cohesive MAB program.

<u>Long-term ecological research and monitoring</u>. Existing biosphere reserve sites are currently collaborating in research concerning atmospheric chemistry and its integration into forest canopy, streamflow, litter layer, and soils. Another interdisciplinary research team is conducting a variety of studies on the condition of threatened high-elevation spruce-fir forests. These research programs have brought together leading scientists to address complex issues of paramount importance in the region. Future collaborative efforts will likely explore the potential effects of global climatic change, most likely in conjunction with the International Geosphere-Biosphere Program scheduled to begin about 1990, which will provide a perspective on the interactive physical, chemical, and biological processes that regulate the total Earth system. There is ongoing discussion of an internationally sponsored Earth-observing system to include remote-sensed observation from satellites and an Earth-based network of biospheric observatories. The SAMAB

program provides an outside aegis for planning and participation of Southern Appalachian agencies and institutions in such a program, which could furnish scientific information of practical benefit to the region as well as for assessing the causes and effects of global change (Gilbert 1988).

Baseline inventory of natural and human resources in the region. State and federal programs in this area abound, and collaboration under the MAB aegis would prove useful and cost-effective. The Smithsonian MAB protocol for biological inventory in selected species-rich sites in the tropics may be applied in the Southern Appalachians. The State of Tennessee, Tennessee Valley Authority, USDA Forest Service, and National Park Service are all involved in a collaborative effort to use the Nature Conservancy inventory system for tracking rare and endangered species. USMAB has recently funded the initiation of an automated graphics interaction system for the Southern Appalachian region for use by conservation, research, and development agencies participating in the SAMAB program.

Conclusion

The stage is set in the Southern Appalachians for a significant increase in activity related to the Man and Biosphere program. Certainly, the region has pressing environmental and economic concerns that require immediate attention. To address these challenges, the region has an extraordinary pool of research, regulatory, and management talent represented in a wide variety of agencies and institutions. If the Man and Biosphere template can become an effective facilitator of channeling this talent pool in a cohesive way to meet these challenges, then maybe the region can serve as a model elsewhere for sustaining natural resources and economic development through deliberate and proactive cooperation among federal, state, local, and private authorities.

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CASE STUDY: PROPOSED ADIRONDACK - LAKE CHAMPLAIN BASIN BIOSPHERE RESERVE

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ABSTRACT: The natural environment, including geology and hydrology, vegetation, and fish and wildlife are sketched together with the framework of natural resources protection and management for a proposed Adirondack-Lake Champlain Basin Biosphere Reserve of nearly 4 million ha (10 million acres). The wilderness areas and wild lands of the New York State Forest Preserve inside the Adirondack State Park, together with the designated federal wilderness areas of the Green Mountain National Forest and one small proposed wilderness island, are recommended as the conservation and monitoring core of the biosphere reserve. The remaining public and private lands of the Adirondack Park are described as a buffer area for research, education, tourism and traditional agricultural and forestry activities. The portion of the Lake Champlain drainage basin outside the Adirondack Park in New York, Vermont and the Canadian Province of Quebec is described as a cooperative area of research, tourism and traditional commercial activity.

KEY WORDS: Adirondack, biosphere reserve, Champlain, Green Mountain, Lake Champlain, New York, Quebec, UNESCO, Vermont, wilderness.

Introduction

In December, 1986, an Ad Hoc United States-Canadian Panel on Biosphere Reserve Selection reviewed a series of candidate sites for nomination as biosphere reserves within the Lake Forest Biogeographical Province (Francis and Gregg 1986). The report rated each of the candidate sites on representativeness and diversity, effectiveness as a conservation unit, naturalness, educational research value and uniqueness. The Lake Champlain drainage basin of New York, Vermont and Quebec scored 91 of a possible 100 in this rating.

The Ad Hoc Panel recommended the Lake Champlain Basin for biosphere reserve nomination and further endorsed the inclusion of the entire Adirondack Park if New York State was supportive. This paper, and the accompanying poster session at the Fourth World Wilderness Congress, outlines a rationale in support of a large Adirondack-Lake Champlain Basin Biosphere Reserve of about 3,967,383 ha (9,799,438 acres). The paper briefly reviews the natural environments and describes the regional framework of natural resources protection and management in the Adirondack and Lake Champlain Basin region. Finally, the proposal is discussed in terms of the Action Plan (UNESCO 1984) and expressed concerns (Batisse 1986) of biosphere reserve criteria.

Setting

The Adirondack Park was created by the New York State Legislature in 1892 to more clearly focus the area where the state would acquire lands for the New York State Forest Preserve that was established in 1885 (VanValkenburgh 1979). The Adirondack Park, as subsequently enlarged, continues to be a mix of privately-owned land and state land in northeastern New York that essentially conforms to the massif of crystalline Precambrian rocks known as the Adirondack Mountains (Fig. 1). The Adirondack Mountains are bordered by a series of lowlands that lie mostly outside the park. These include the St. Lawrence River Valley to the north, the Black River Valley to the west that drains into Lake Ontario, the Mohawk River Valley to the south that drains into the Hudson River, and the Lake Champlain Valley to the east (Fig. 2).

The Lake Champlain Basin was studied intensively (NERBC 1978a and 1979) as part of a comprehensive, coordinated joint plan for the conservation and utilization of New England's land and water resources. The basin includes the lowlands of the Lake Champlain Valley and the lake itself. It also includes portions of the Green Mountains, Taconic Mountains, Great Valley and Piedmont of Vermont (Fig. 3). The Lake Champlain Basin drains north to the Richelieu River and eventually the St. Lawrence River.

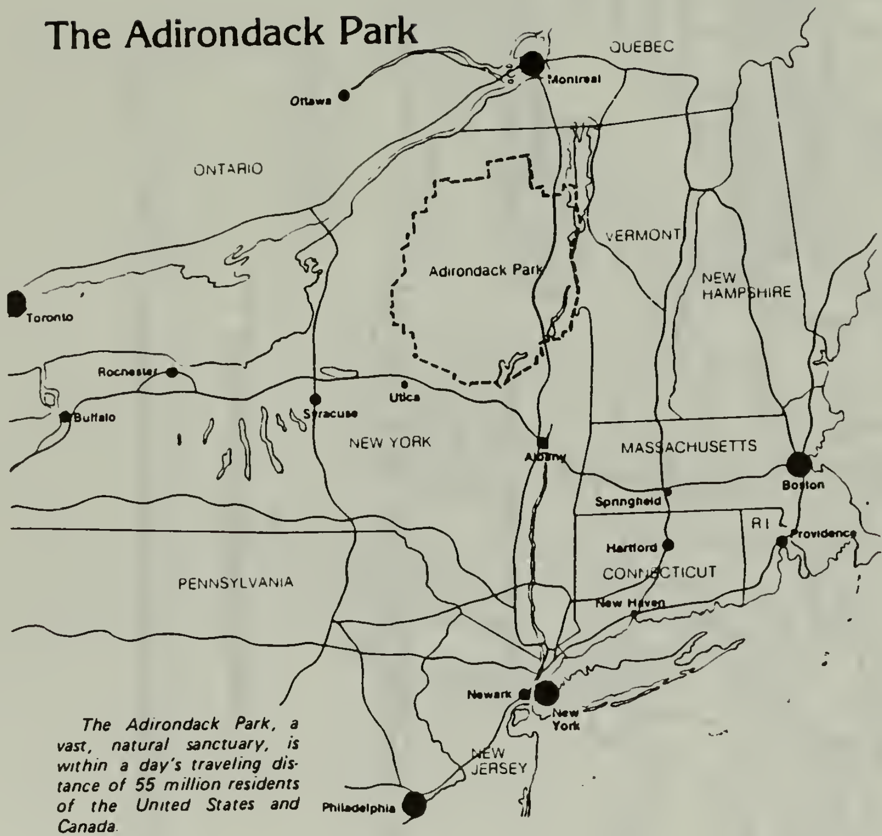
While all of the Adirondack Park lies in New York State, the Lake Champlain Basin lies in New York and Vermont and a portion is in the Province of Quebec, Canada. Table 1 shows the total area of the several component parts of the proposed biosphere reserve, while Table 2 describes the area of the components without regard to their overlapping land areas.

Natural Environment

Geology/Hydrology

The Precambrian rocks of the Adirondacks are a southern extension of the large Grenville province of the Canadian Shield (Wiener et al. 1984). The early complex geologic history of the region was significantly affected by the Grenville Orogeny, a mountain-building event (1100 million years ago) that subjected the preexisting rocks to multiple folding, metamorphism and intrusive activity. Subsequent uplift and erosion has left a complex highland area composed of several low mountainous ridges separated by northeast/southwest trending valleys. The highest of the mountain peaks exceed 1640 m (5000 feet), but generally elevations range between 820 m (2500 feet) and 1310 m (4000 feet). The bedrock of the surrounding lowland areas consists of unmetamorphosed shelf sandstones and limestones of the lower Paleozoic (450-550 million years).

The bedrock geology of Vermont east of the lower Paleozoic rocks of the Champlain lowland consist of a series of older Paleozoic sedimentary rocks that were thrust from east to west over the Paleozoic rocks of the Champlain lowlands. These thrust faults generally parallel the eastern shore of present-day Lake Champlain. To the south, the Taconic region (Fig. 3) has a similar thrust fault history. To the east, the Green Mountains are formed by a complex, anticlinorial fold that has an exposed core of older, highly metamorphosed Cambrian and Precambrian schists (Thompson 1972). This complex metamorphic province continues eastward to include much of the Vermont piedmont (Doolan and Stanley 1972). The thrust faults, regional metamorphism and intrusives of



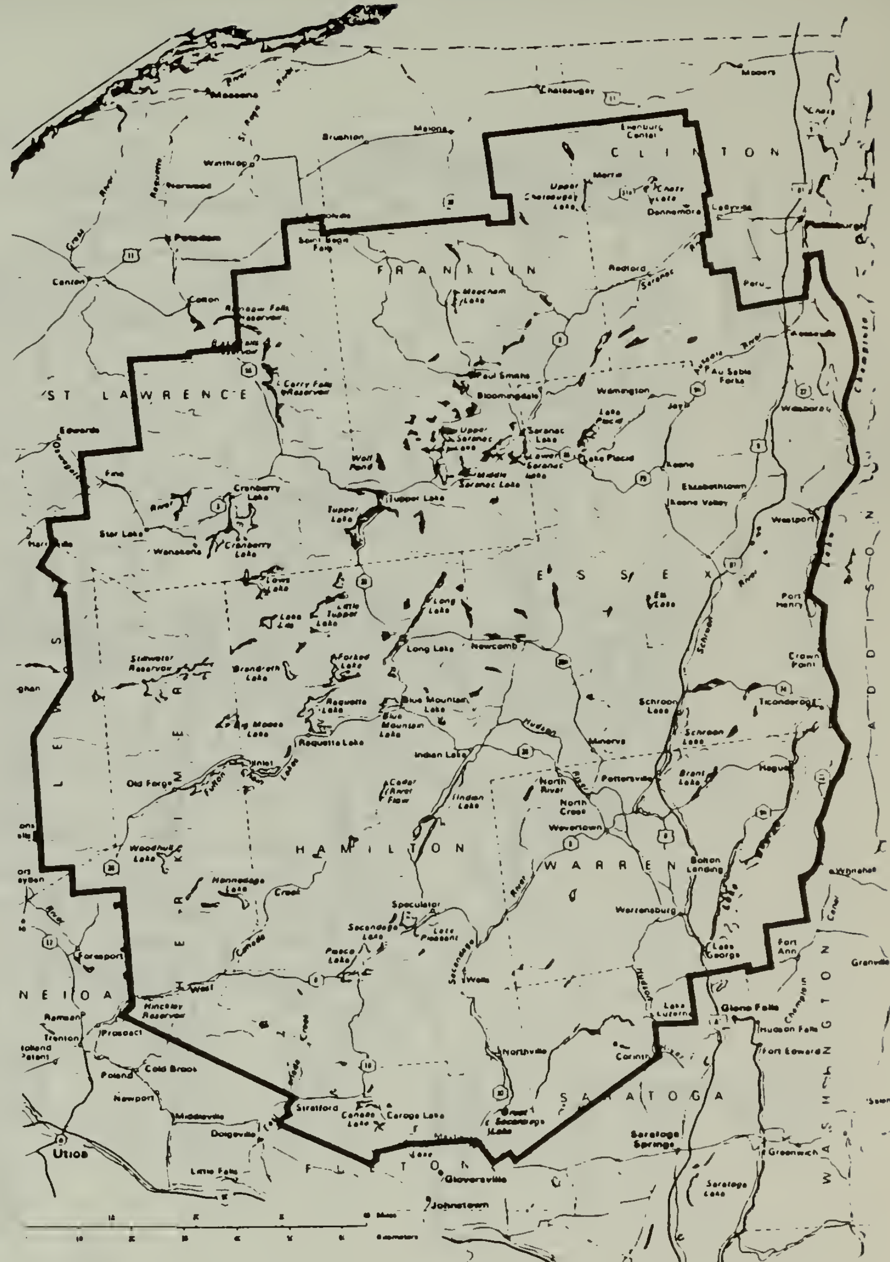


Figure 1. Location of the Adirondack Park (above) and political divisions of the Adirondack Park (right).

Figure 2. Major drainages of the Adirondack region (NYS-DEC 1971).

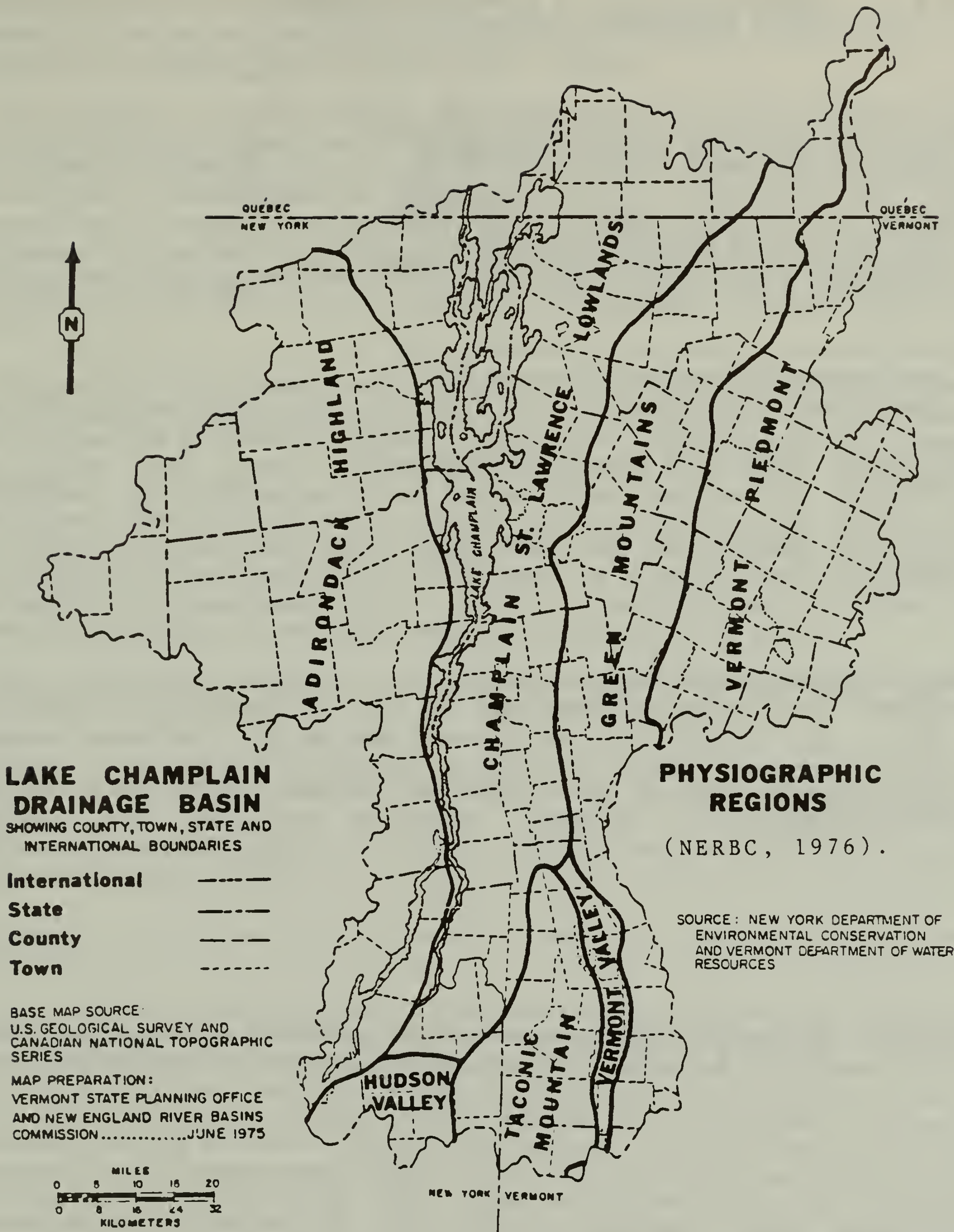


Figure 3. Physiographic regions of the Lake Champlain drainage basin.

Table 1. Components of the proposed Adirondack - Lake Champlain Basin Biosphere Reserve.

	Hectares	Acres
Portion of New York's Adirondack Park outside the Lake Champlain Basin.	1,833,878	4,529,680
Portion of New York's Adirondack Park inside the Lake Champlain Basin, including the portion of Lake Champlain inside the Adirondack Park.	565,992	1,398,000*
Portion of New York State outside the Adirondack Park, but, inside the Lake Champlain Basin.	223,513	552,078
Portion of Quebec in the Lake Champlain Basin.	149,247	368,640
Portion of Vermont in the Lake Champlain Basin.	1,194,753	2,951,040
Total proposed Adirondack - Lake Champlain Biosphere Reserve.	3,967,383	9,799,438

* estimate provided by the Cartographic Department, Adirondack Park Agency.

Table 2. Elements of the proposed Adirondack - Lake Champlain Basin Biosphere Reserve with overlap disregarded.

	Hectares	Acres
New York's Adirondack Park	2,399,870	5,927,680
Lake Champlain Basin	2,132,642	5,269,758
Lake Champlain surface water area	114,008	281,600

Vermont are evidence of Grenville activity and of a significant younger period of Late Ordovician mountain-building (440 million years ago) associated with the margin of the North American plate at the time of the Taconic Orogeny.

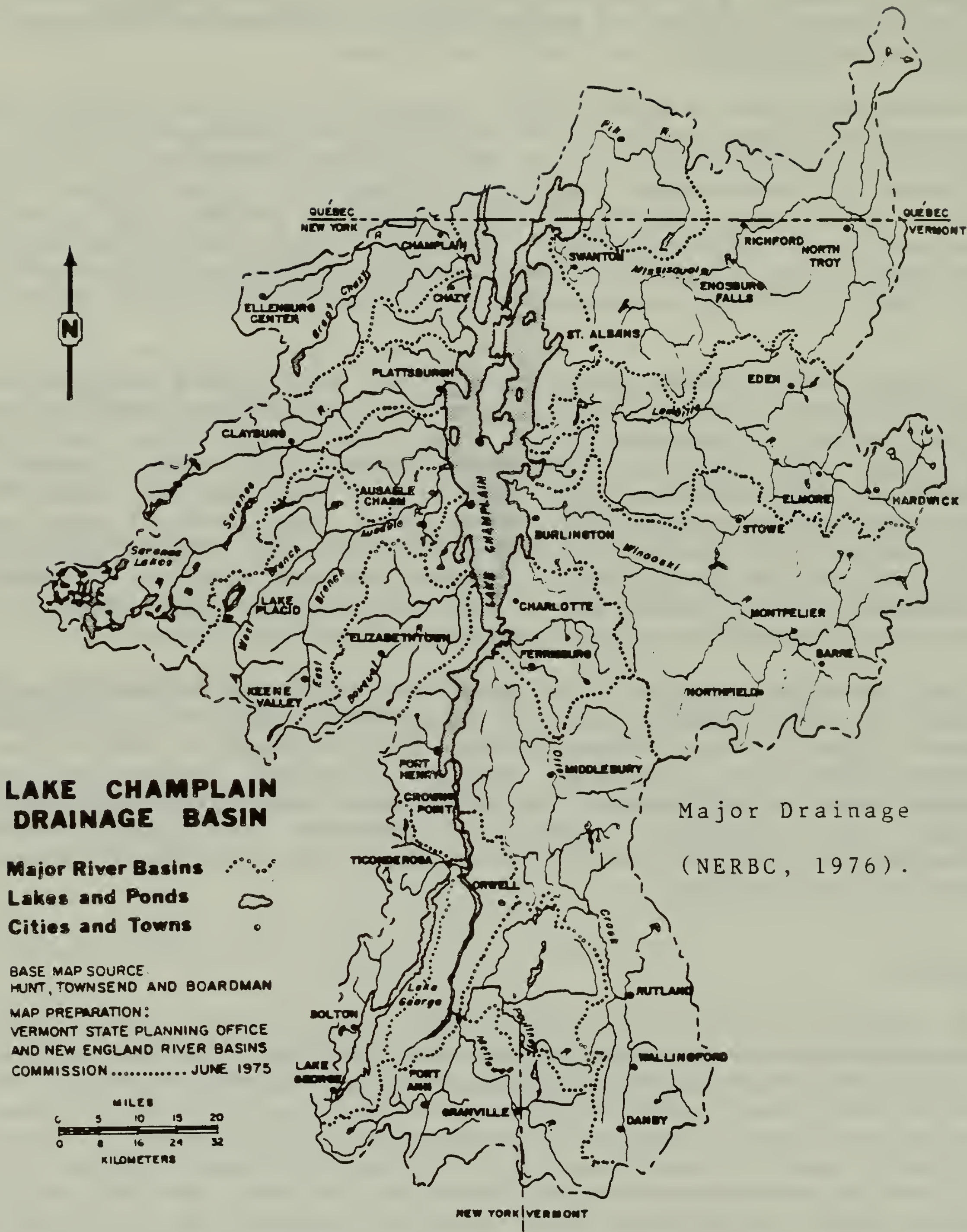
The subsequent bedrock geology of the Adirondacks and the Lake Champlain Basin is little known until it was modified by the Pleistocene glacial advances and retreats. Many of the zones of weakness created by the thrust faults and sedimentary rocks and marbles were eroded by the succession of advancing ice sheets to produce the Great Valley of Vermont, the lowlands, including the Lake Champlain lowlands, that surround the Adirondacks and the series of northeast to southwest trending valleys that separate the various ranges of the Adirondacks. These erosion patterns are further complicated by the eskers, glacial lake deltas and moraine sediments deposited as ice sheets melted (Denny 1974).

The legacy of the complex geologic history of the Adirondacks is a highland area that serves as a headwater collection and storage area for the significant rivers and lakes that form parts of the St. Lawrence River (St. Regis River, Raquette River and Tupper and Long Lakes, Grass River and Oswegatchie River), Black River (Beaver River, Independence River and Moose River), Mohawk River (East and West Canada Creeks), upper Hudson River (Sacandaga River, Schroon Rivers, Cedar River and Indian Lake) and Lake Champlain (Great Chazy River, Saranac River and Lakes, Ausable River and Lakes, Boquet River and Lake George) (Fig. 2). Similarly, the Green Mountains of Vermont form the headwaters of the eastern side of the Lake Champlain Basin (Missisquoi River, Lamoille river, Winooski River, Otter Creek and Poultney River) (Fig. 4).

These headwaters comingle in the higher elevations of the Adirondacks and Green Mountains in areas of shallow lakes and wetlands often separated by low, glacially-deposited ridges that form drainage divides. The full lengths of most of the rivers mentioned above have traditionally provided recreational opportunities from the headwater areas to the lowlands. As these rivers leave the highland areas, they frequently form spectacular waterfalls. Hydropower development has created impoundments at 22 sites in New York and 44 sites in Vermont (APA 1981; Ruzow 1981; Vermont AEC 1974 and 1986).

Vegetation

The Adirondack Park is 85 percent forested and the Vermont portion of the Lake Champlain Basin is over 70 percent forested with variations of the boreal spruce-fir and northern hardwood forest zones being dominant (Davis and Huber 1971; Meeks 1986). The spruce-fir zone is found mainly with black spruce and tamarack in low wet areas, while red spruce and balsam fir dominate at elevations over 760 m (2500 feet). The spruce-fir is frequently mixed at lower elevations with northern hardwoods dominated by yellow birch, American beech and sugar maple. Other trees and shrubs associated with northern hardwoods include red and striped maple, white ash, basswood, elm, red and white oak, shagbark hickory, butternut and rarely American chestnut. Locally, white pine and hemlock can exist as pure stands surrounded by hardwoods or as strong components of the hardwood zone. Where fires or other disturbances have occurred, paper birch and aspen may dominate as the early pioneer species of the spruce-fir and northern hardwood zones (Hamilton et al. 1980; Hardy and Askew 1980).



Major Drainage

(NERBC, 1976).

Figure 4. Major drainages of the Lake Champlain drainage basin.

The upper reaches of the spruce-fir zone above 1220 m (4000 feet) is a climatically harsh subalpine zone that stunts tree growth. Balsam fir dominates the occasional dwarf black spruce in this zone (Davis 1977). Above this, the High Peaks of the Adirondacks have less than 40 ha (100 acres) of alpine tundra, while the Green Mountains have another 100 ha (250 acres) on Mt. Mansfield and 4 ha (10 acres) on Camel's Hump. These fragile alpine areas contain vegetation that survived the Pleistocene glacial epoch. Half of the alpine area is exposed rock with lichens and mosses that are just beginning to form soil. The remaining area is irregularly covered with alpine plants that include mountain sandwort, Lapland rosebay, Diapensia, Bigelow's sedge, alpine bilberry and others (DiNunzio 1984; Johnson, 1980).

Fish and Wildlife

The distribution of wildlife in the Airondacks and Lake Champlain Basin varies with elevation and forest cover (Kelley et al. 1981). The more isolated stands of mature and regenerating spruce-fir and northern hardwoods support wilderness wildlife such as black bear, fisher, pine marten and ravens, along with some white-tailed deer and varying hare. Lowland areas dominated by dairy farms, crop farming and orchards support moderate populations of farmland and forest edge species such as cottontail rabbit, raccoon, white-tailed deer, ruffed grouse and gray squirrel (Clarke 1971).

Lake Champlain is also an important flyway and its 13,000 ha (32,000 acres) of shore wetlands (Brooks 1979) serve as major waterfowl nesting, resting and feeding sites. The Adirondacks contain over 365,000 ha (900,000 acres) of diverse wetland types (DiNunzio 1984). These wetlands are of unparalleled value as habitat for small mammals, including beaver, otter, muskrat and mink; shorebirds; varieties of reptiles and amphibians; and fish-spawning areas. Some wetlands provide significant deer wintering areas (Johnson 1985).

The fish of the Adirondacks and Lake Champlain Basin have been studied extensively and nearly one hundred species are known, with twenty or so being sought by anglers (NERBC 1976). The fish species can be generally viewed as groups derived from the melting of the last glacial advance. In the Adirondacks, nearly half the fish species are derived from Mississippi Valley and adjacent Pleistocene refugia, while the remaining species are upland boreal species or are derived from Atlantic Pleistocene refugia (George 1981). Significant stocking programs are conducted for game fish in New York and Vermont under state management programs (Pfeiffer 1979; Keller 1979; Engstrom-Heg 1979). The impact of acid precipitation on Adirondack fisheries has been of concern since the early 1970s (Pfeiffer and Festa 1980; Colquhoun et al. 1984) and significant studies continue (ALSC 1986).

In recent years, New York and Vermont have both supported Heritage Programs to conduct field searches for plant and animal communities considered to be rare within the states or globally. Of the larger animals that once occupied the Adirondacks, cougar, lynx, timber wolf, elk, woodland caribou, wolverine, moose and peregrine falcon are now extirpated (Clark 1971; Benson and Chase 1971; Peterson 1979). Programs to reintroduce the peregrine falcon and the lynx and to monitor an apparent natural return of moose are currently supported by New York.

New York

Within the Adirondack Park, the responsibilities for policy formulation and management of natural resources are shared by the New York State Department of Environmental Conservation and the Adirondack Park Agency. The Agency is responsible for the Land Use and Development Plan (APA 1971 and 1983) for private lands. This natural resource-based plan classifies private land in six classifications (resource management, rural use, low intensity, moderate intensity, industrial and hamlet) subject to limitations that include restrictions on the density of principal buildings, shoreline setbacks and cutting restrictions. The APA is responsible for reviewing projects of regional significance; but it defers the review of lesser projects to those towns that have approved zoning plans. Within the Adirondack Park, the APA also administers the New York Wild, Scenic and Recreational Rivers Act (ECL 1987) that includes over 1900 km (1200 miles) of Adirondack rivers, and the New York Freshwater Wetlands Act (ECL 1987) which applies to all wetlands over 0.4 ha (1 acre).

The APA is also responsible for formulating, subject to the governor's approval, the Adirondack State Land Master Plan (APA 1985). This policy document classifies the state land in the Adirondack Park into nine classifications (wilderness, canoe, primitive, wild forest, intensive use, administrative, historic, WSR rivers and travel corridors) and provides guidelines for their management and use. Each of the units of land within the classifications is managed according to a unit management plan usually drafted and implemented by the NYS Department of Environmental Conservation and approved by the Commissioner of Environmental Conservation. The NYS Department of Environmental Conservation also has a broad range of natural resource management responsibilities throughout New York State. These include responsibilities for implementing the state's environmental quality review law, and laws relating to water quality, water resources, air quality, state land acquisitions, forest, fish and wildlife programs, hazardous and solid waste, coastal resources, mineral resources and tidal wetlands. Outside the Adirondack Park, the Department is also responsible for the WSR rivers programs and for freshwater wetlands in excess of 5 ha (12.4 acres) (ECL 1987).

Vermont

Within Vermont, the Agency of Natural Resources (formerly the Agency for Environmental Conservation) is responsible for policy formulation and management of natural resources. Their responsibilities include air quality, water quality and water resources, hazardous and solid waste, fish and wildlife and parks and recreation. Since 1970, Vermont's Land Use and Development Act (Act 250) has granted authority to nine District Commissions to review projects and issue permits for projects that trigger a statutorily defined threshold of size or type in accordance with ten criteria (Garland 1979).

The Green Mountain National Forest and the Missisquoi National Wildlife Refuge are the only significant units of federal land in the Adirondack and Lake Champlain Basin region. The Green Mountain National Forest includes 131,741 ha (325,400 acres) in two sections that straddle the Green Mountains on the eastern edge of the Lake Champlain Basin (Fig. 5). About one-third of the national forest is in the Lake Champlain Basin

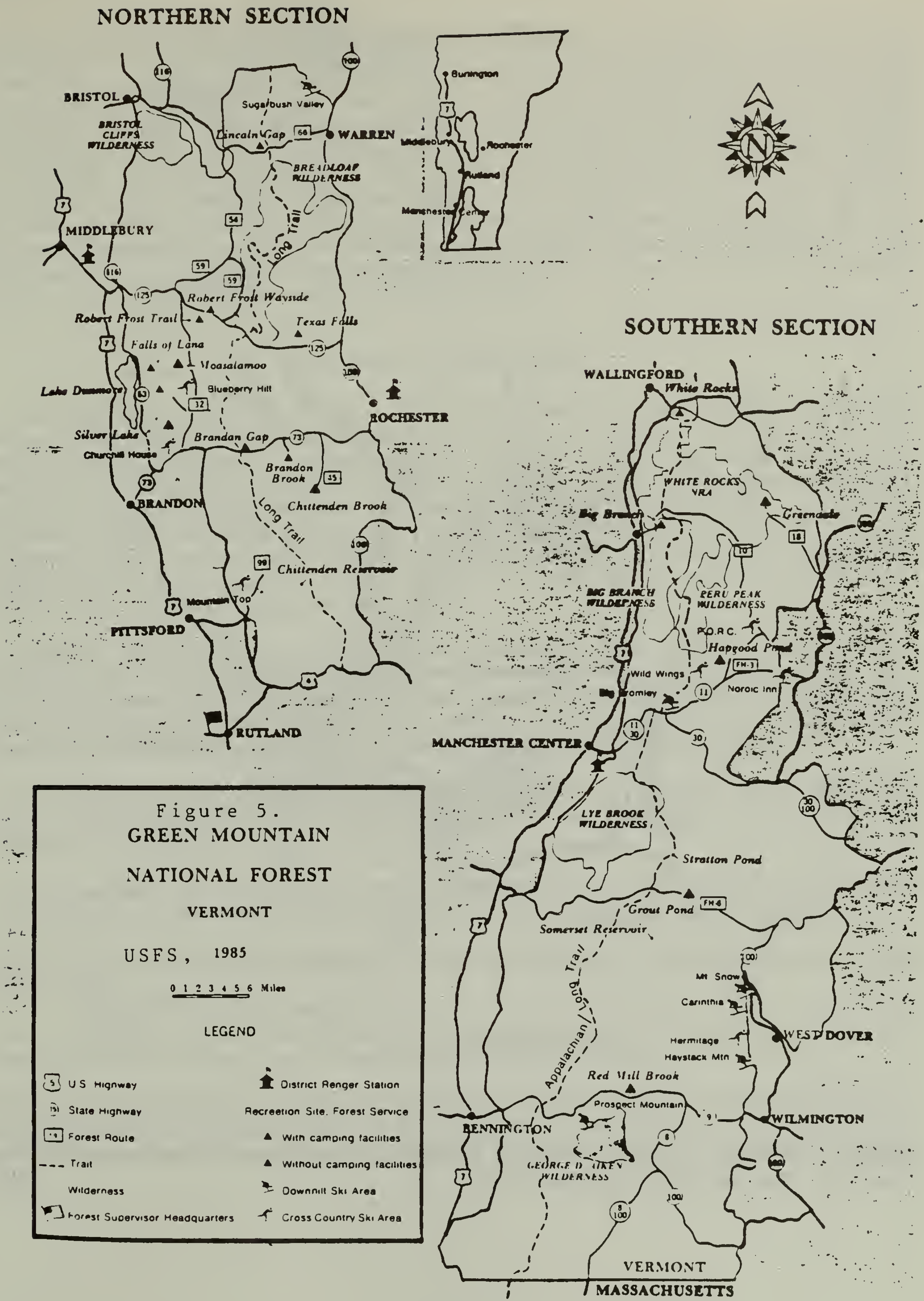


Figure 5.
GREEN MOUNTAIN NATIONAL FOREST
VERMONT
USFS, 1985

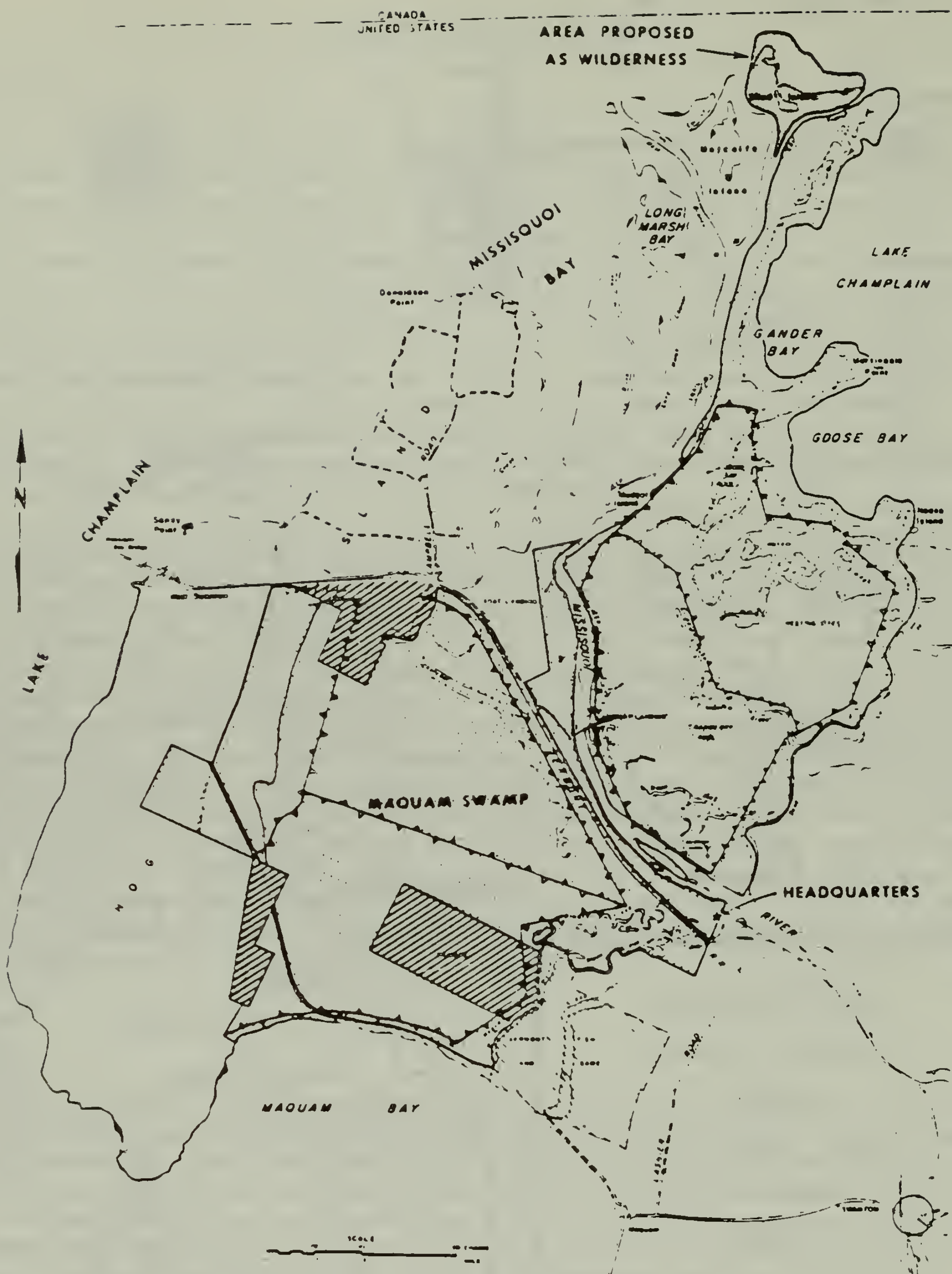


Figure 6. Missisquoi National Wildlife Refuge and the proposed Shag Island Wilderness Area (U.S. Fish and Wildlife Service 1973).

and this portion includes all of the Big Branch Wilderness Area (2721 ha or 6720 acres), all of the Bristol Cliffs Wilderness Area (1513 ha or 3738 acres), almost all of the Peru Peak Wilderness Area (2802 ha or 6920 acres) and 70 percent of the Broadleaf Wilderness Area (total 8696 ha or 21,480 acres). The George D. Aiken Wilderness and the Lye Brook Wilderness, the only Green Mountain wilderness where special air quality standards must be maintained under the National Clean Air Act, lie entirely outside the Lake Champlain Basin (USFS 1985, 1986 and 1987). In addition to the wilderness, 4900 ha (13,100 acres) of the national forest, including a portion in the Lake Champlain Basin, is managed as a primitive recreation land with no roads, no timber harvesting and few people. The U.S. Fish and Wildlife Service manages the Missisquoi National Wildlife Refuge (Fig. 6). This 1941-ha (4794-acre) wetland in the northern part of Lake Champlain includes Shag Island, a 46-ha (114-acre) wilderness proposal (USFWS 1973).

Biosphere Reserve Proposal

The Adirondack-Lake Champlain Basin region straddles the same two global biomes, temperate broadleaf forests and temperate needleleaf forests, as the Lake-Forest Biogeographical Province. It includes Lake Champlain, its drainage basin, and a broad diversity of ecosystems in several additional drainage basins in the Adirondack Park. Although the proposed area is large and is governed by three political units, it is broadly composed of two cohesive regions, the Adirondack Park (White 1980) and the Lake Champlain Basin (Carlozzi and Prosnitz 1979) that have a long tradition of being viewed as units by both their inhabitants (Trancik 1983 and 1985) and natural resource managers (NERBC 1978b).

Biosphere reserves provide opportunities to enhance research, monitoring, training, education and local participation (UNESCO 1984). They also bring opportunites for a region to broaden its perspective so that its regional research activities become familiar to an arena of international scholars. For example, several areas in Asia and Europe also straddle the temperate broadleaf and needleleaf forest biomes. These include:

1. A boundary that extends 2200 km (1400 miles) from the Gulf of Finland in the eastern Baltic, generally east along 55°N latitude, to the Tobol Irtysh River 40 km (250 miles) east of Sverdlovsk, USSR.

2. A boundary that generally follows the China/USSR border for 2800 km (1800 miles) from the Sea of Japan north, then west along the Ussuri, Amur and Shilka Rivers.

3. Small sections that latitudinally cross the peninsula of South Korea and Honshu Island, Japan.

4. A boundary that wanders generally southwest for 2700 km (1700 miles) from Hangchow Bay, East China Sea, across southern China to Burma.

Research and monitoring of ecological systems in existing or future biosphere reserves in the biogeographical provinces that straddle these biome boundaries would be particularly useful if shared with the scholarly community of the Adirondack and Lake Champlain Basin.

For a biosphere reserve to achieve success, it should carry out basic conservation, sustainable development and information-sharing functions (UNESCO 1984). These functions have been discussed in spatial terms using a conceptual zonation, including a conservation and monitoring core area, buffer zones for reseach, education, tourism, multiple use and sustainable development, and transition areas of cooperation (Batisse 1986).

Proposed Core Area

The Adirondack-Lake Champlain Basin includes several land classes that are strictly protected and which satisfy the core criteria. The seventeen wilderness and canoe areas of the Adirondack Park, including the proposed upgrading of the Jay Primitive Area, constitute 433,143 ha (1,069,864 acres) that are protected in much the same fashion as the United States federal wilderness system by the Adirondack State Land Master Plan (APA 1971 and 1985) and by Article 14 of the New York State Constitution. The first sentences of Section 1 of Article 14 state:

> "The lands of the state now owned or hereafter acquired, constituting the forest preserve as now fixed by law, shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed" (NYS Department of State, 1984).

To these lands it would be reasonable to add the eighteen primitive areas, except the Jay area included above, and fifteen wild forest areas that together constitute 561,988 ha (1,388,110 acres) also protected by Article 14. Primitive areas (APA 1985) may have certain specified structures, improvements or inholdings that are not fully consistent with wilderness; however, in a broader context, these exceptions are relatively minor. Wild forest areas (APA 1985) retain an essentially wild character, but may be less remote and may offer a broader range of recreational activity than wilderness, including some motorized use. Although wild forest areas may have a higher degree of human use than wilderness, the protection of Article 14 precludes many research activities that would involve substantial tree cutting. In addition, remote sections of some wild forest areas are being designated as trailless areas in unit management plans, thus encouraging their continued remoteness (NYS-DEC 1987, page 53).

Four designated federal wilderness areas in the Green Mountain National Forest (13,123 ha or 32,414 acres) lie entirely or partly in the Lake Champlain Basin (USFS 1986). In addition, the proposed Shag Island wilderness in the Missisquoi National Wildlife Refuge is on Lake Champlain. Each of these wilderness and proposed wilderness areas is managed in accordance with the provisions of the National Wilderness Preservation Act and would be suitable as part of the core area.

In total, the proposed core area includes over one million hectares (2.5 million acres) in three dozen management units, ranging from the 46-ha (114-acre) Shag Island to the 91,674-ha (226,435-acre) High Peaks Wilderness Area and including the Valcour Island Primitive Area (435 ha or 1075 acres) in eastern Lake Champlain.

Proposed Buffer Zone

The Adirondack-Lake Champlain Basin proposal includes a substantial buffer zone that is strictly delineated by a New York State statute that defines the meets and bounds of the "blueline" that forms the boundary of the Adirondack Park (ECL 1987, Section 9-0101). Specifically, the Adirondack Park, less the clearly defined units of state land described above as part of the core area, makes a 1,404,739-ha (3,469,705-acre) buffer of mostly private and some intensively managed state land that has its natural resources jointly managed by the Adirondack Park Agency and the NYS Department of Environmental Conservation. The private land in the Adirondack Park includes 794,000 ha (1,961,000 acres) of land classified as resource management (APA 1976). Development in this land class is limited in a variety of ways, including a limit of fifteen principal buildings per square mile (259 ha) (APA 1971) because of shallow soils, severe slopes and other limiting natural resource conditions. These lands are broadly representative of the ecosystems of the proposed core area and are managed to enhance their forest, agricultural, recreational and open space resources.

The possibility of adding all of the Missisquoi National Wildlife Refuge, except Shag Island and that portion of the Green Mountain National Forest except for the wilderness areas within the Lake Champlain Basin, should be considered. Both of these units are defined by federal statute and each is essentially managed by a single federal agency.

The proposed buffer is ideally suited for a wide variety of natural resource research and education activities. Examples of existing research and teaching facilities include:

1. New York State College of Environmental Science and Forestry, Syracuse, NY
    a. Cranberry Lake Campus
    b. Newcomb Campus, including the Archer and Anna Huntington Wildlife Forest and Adirondack Ecological Center
    c. Warrensburg Campus, including the Charles Lathrop Pack Demonstration Forest

2. North Country Community College, Saranac Lake, NY

3. St. Lawrence University Conference Center

4. State University of New York (SUNY) - Albany Atmospheric Sciences Research Center

5. SUNY-Cortland - Huntington Memorial Camp

6. SUNY-Potsdam - Star Lake Campus

A variety of conference centers and non-collegiate educational opportunities also exist within the proposed buffer zone. Examples include the nature preserves of the Adirondack Conservancy Chapter, Adirondack Adventures, Pok-O-MacCready Outdoor Education Center, Silver Bay Association, and Sagamore Lodge and Conference Center. Many private tourist facilities exist within the proposed buffer, and others, such as the Olympic facilities, state compgrounds, state and county fish hatcheries and two state visitor information centers under construction, are operated by government agencies.

There are dozens of art centers and galleries, craft stores and studios, museums including the renowned Adirondack Museum at Blue Mountain Lake, New York, theaters, music festivals and sports activities (Kirschenbaum et al. 1983) in the area considered suitable as a buffer zone.

The private land plan (APA 1971) designates about 30,000 ha (74,000 acres) as hamlet areas that are intended to accommodate the natural expansion of housing needs, commercial and industrial growth and development (APA 1976). In addtion, agriculture and forestry continue as significant traditional Adirondack industries in the buffer zone. These traditional industries tend to preserve the open space that characterizes all of the Adirondack Park (Verner 1980). Recently, the Environmental Quality Bond Act (ECL 1987, Article 52) provided additional monies for the state acquisition of conservation easements. Private sector incentives for the protection of open space with conservation easements has been enhanced recently with the formation of the Adirondack Land Trust (Davis and Duffus 1987).

Proposed Transition Area

The Lake Champlain drainage basin outside the Adirondack Park is proposed as a 1,567,513-ha (3,871,758-acre) transition area or zone of cooperation that is partly in New York, Vermont and Quebec. Although it is not strictly delineated in political terms, this transition area, when combined with the portion of the Lake Champlain Basin inside the Adirondack Park, makes up the entire drainage of Lake Champlain. This drainage basin ultimately controls the water quality of Lake Champlain (NERB 1976) and is the "great lake" that makes the Adirondack-Lake Champlain Basin representative of the Lake-Forest Biogeographical Province. The transtion area includes the major population centers of Vermont, including Burlington, Winooski, Montpelier, St. Albans and Rutland. It also includes the Plattsburgh, Champlain-Rouses Point and Whitehall-Granville areas of New York, as well as smaller population centers in Quebec. In addition to the college facilities noted in the core area, the University of Vermont and SUNY-Plattsburgh provide teaching and research opportunities. The College of Agriculture, University of Vermont, and the William H. Miner Agricultural Research Institute, Chazy, New York, share agricultural and teaching research projects. An extensive variety of tourist, cultural, educational and traditional use activities have developed in the proposed transition area that is much too extensive to document in this brief summary report.

Conclusion

This paper outlines a proposed conceptual basis for an Adirondack-Lake Champlain Basin Biosphere Reserve. This paper has briefly reviewed the natural resources of the region and the existing institutional arrangements for the protection of natural resources. The spatial distribution of biosphere reserve functions has been outlined. The region is extremely diverse and considerable ad hoc cooperation already exists among those responsible for management and those involved in research. But this is not enough. Population growth, increased levels of development and external pollution sources all threaten the region's biological heritage. There is a clear need to look forward (Fish 1987) to shape future development and to provide addtional protection to safeguard the region's wild areas and genetic resources.

Biosphere reserve designation will strengthen regional pride and foster an appreciation of the unique relationship of the natural ecosystems of the Adirondack-Lake Champlain region to the region's rich cultural heritage. Existing programs that are designed on an ecological basis to conserve resources over a large area will be enhanced by this designation. This designation will also broaden and encourge the scientific use of designated areas to improve regional and international scientific cooperation. Biosphere reserve designation will provide access to a network of local, regional and international activities to provide a neutral ground for consultation and discussion between agencies, local people and the research community. Finally, biosphere reserve designation will foster a world view of regional and global environmental education in the Adirondack and Lake Champlain region.

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AN ECOSYSTEM CONSERVATION DATABASE FOR THE UNITED STATES

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ABSTRACT. The macroreserve system of the United States is defined as all land or water management units of at least 2,000 ha (5,000 acres) that contain one or more natural ecosystems and are publicly owned, or are privately owned and designated for nature conservation. A national ecosystem conservation database for assessing the protection status of U.S. ecosystem diversity and prioritizing future additions of ecosystems to the U.S. macroreserve system is described. Maps of potential diversity are used to determine the original location of natural ecosystems. This information is then compared with macroreserve maps, onsite inventories of existing diversity, and management objectives to estimate the protection status of each natural ecosystem on each macroreserve. Preliminary nationwide analyses of potential ecosystem diversity and a pilot study in Florida are discussed, along with potential applications, including the selection and evaluation of potential bio- sphere reserves. Development of individual-state databases will provide incremental increases in the accuracy and usefulness of the national database.

KEY WORDS: biological diversity, ecosystem diversity, Indian reservation, land management agency, macroreserve, map analysis, nature conservation, nature reserve, potential natural vegetation, protected area, regionalization, United States.

Introduction

Representative samples of naturally occurring biological diversity in the United States can be most effectively maintained by protecting them onsite in a nationwide system of ecosystem reserves. A partial system of this sort already exists, as a result of many, largely independent, past actions by public and private organizations. Future decisions affecting this system should be better coordinated, in order to build it in a more cost-effective way. As a first step, a computerized method with cartographic and analytical capabilities is needed to provide national monitoring of both natural ecosystem diversity and its protection status. Additions of new protected areas or changes in management of existing ones can then be prioritized on the basis of how well they fill gaps in, or generally strengthen, the overall reserve system. A national ecosystem conservation database designed for this purpose is described and its current level of development is summarized.

The U.S. Macroreserve System

Many federally-managed areas in the United States provide some protection for natural and seminatural ecosystems. They range from relatively well protected wildernesses, ecological research areas, parks, and refuges, through the vast multiple use areas of the Forest Service and Bureau of Land Management, to military installations that practice conservation within the limits set by their primary missions. Indian reservations are an important special category. These lands are owned by the tribes but held in trust for them by the federal government. State governments, and more recently local governments and private organizations, have also created an extensive array of areas that provide various levels of protection for ecosystems. The totality of the larger public and private reserves of the type just described has been called the macroreserve system of the United States (Crumpacker 1985a). A macroreserve is defined as "a land and/or water management unit of at least 2,000 ha (5,000 acres) that contains one or more natural ecosystems and is publically owned, or is privately owned and designated for nature conservation" (Crumpacker 1986). The lower size limit recognizes the need for smaller reserves to protect many climax and nonclimax ecosystems that currently exist only in small habitat fragments or azonally (e.g., some riparian areas and lakes); however, it is much too small to maintain viable populations of the larger avian and mammalian herbivores and carnivores (e.g., see Hoover and Wills 1984; Soule and Simberloff 1986).

Potential Natural Diversity

The type of ecosystem that would eventually become established in an area under prevailing natural conditions can be called a potential natural ecosystem (Crumpacker 1985a). "Prevailing natural conditions" refers to the present abiotic and biotic environments. The latter allows for current effects influenced by earlier Native American activities, as well as future forest and range management activities that do not permanently disturb the landscape and which permit it to remain in a relatively natural condition. "Eventually become established" implies a climax situation, whereby a relatively stable, self-perpetuating biotic community is produced as a result of successional processes over a period of several hundred years. Dominant vegetation can be used to name, describe, and map many potential natural ecosystems because it is the most easily observable integrator of climate, soils, and topography, and tends to correlate with faunal distributions.

Potential natural ecosystems at the national level can be conveniently described by Kuchler's (1964) potential natural vegetation or "PNV" types (Crumpacker, Hodge, Friedley and Gregg 1987). Examples are Alpine Meadows and Barren (*Agrostis, Carex, Festuca, Poa*), Juniper-Oak Savanna (*Andropogon-Quercus-Juniperus*), Elm-Ash Forest (*Ulmus-Fraxinus*), and Mangrove (*Avicennia-Rhizophora*). The dominant plant genera are shown in parentheses. At this level of generalization it is reasonable to assume that many, if not most, of the Kuchler types were the pre-European settlement types of 100 to 300 years ago. They therefore provide an appropriate means for describing the full range of major, natural, above-ground, terrestrial and wetland ecosystem diversity that should be protected in a comprehensive national conservation program.

Use of Kuchler PNV types to represent U.S. ecosystem diversity in conservation planning has two important consequences. The first results from the meaning of potential natural vegetation, which implies an informed prediction about the biotic potential of a part of the earth's surface. A site in California "predicted" to be "Tule Marshes" on a Kuchler map may actually be covered by rice fields, vineyards, or the city of Stockton. Something of this sort is in fact likely, because "Tule Marshes" was estimated to have suffered, by 1967, more conversion to other land uses than any other Kuchler type (Klopatek, Olson, Emerson and Joness 1979). Thus a cartographic analysis that shows that a portion of the Tule Marshes PNV type is located within the boundaries of Travis Air Force Base, California, does not prove that it exists there. The analysis indicates only that it would be expected to occur there under natural conditions. Large discrepancies between expected and observed PNV types may also occur under natural conditions. For example, a PNV map site in southeastern Alaska designated as Hemlock-Spruce Forest may be represented on the ground by an earlier successional stage of tundra or shrub thicket that has resulted from a relatively recent natural disturbance. A map survey of the protected status of potential ecosystem diversity must, therefore, be viewed as a preliminary survey. The advantages of using potential ecosystem diversity are as follows (Crumpacker 1986):

1. Maps of potential diversity identify and locate the full array of ecosystems that should be protected in healthy, representative samples in a comprehensive macro-reserve system.

2. Maps of potential diversity are relatively stable constructs, whereas maps of existing diversity can change dramatically over time, especially as a result of human disturbance.

3. Maps of existing diversity at state, regional, or higher levels are generally based on remote sensing and do not yet distinguish adequately among many plant genera and species.

4. If a potential ecosystem is found from a preliminary, map-based survey to be inadequately protected because it does not occur within the boundaries of any macroreserve, then it is very likely that existing samples of that ecosystem are also inadequately protected, and little or no additional analysis may be needed to demonstrate this finding.

The second important consequence of using Kuchler PNV types to describe ecosystems involves the very large amount of climax and nonclimax diversity which they represent. Southern Mixed Forest in Florida (Fig. 1) can be shown by comparison of identical locations on Kuchler, Davis, and SCS maps to contain a number of component ecosystems. Additional, non-spatial cross-referencing with other classification systems shows that Southern Mixed Forest consists of several Florida Natural Areas Inventory (FNAI) natural communities, each of which, in turn, is likely to contain several FNAI plant communities. The latter are analogous to plant associations (Daubenmire 1968), which represent the lowest level of terrestrial and wetland ecosystem classification that can be consistently identified and realistically dealt with in a conservation program. Although not shown in Fig. 1, there are at least 15 well-defined FNAI natural communities in the Southern Mixed Forest type. The number of different FNAI Plant communities is presently unknown because this level of vegetation classification has not yet been

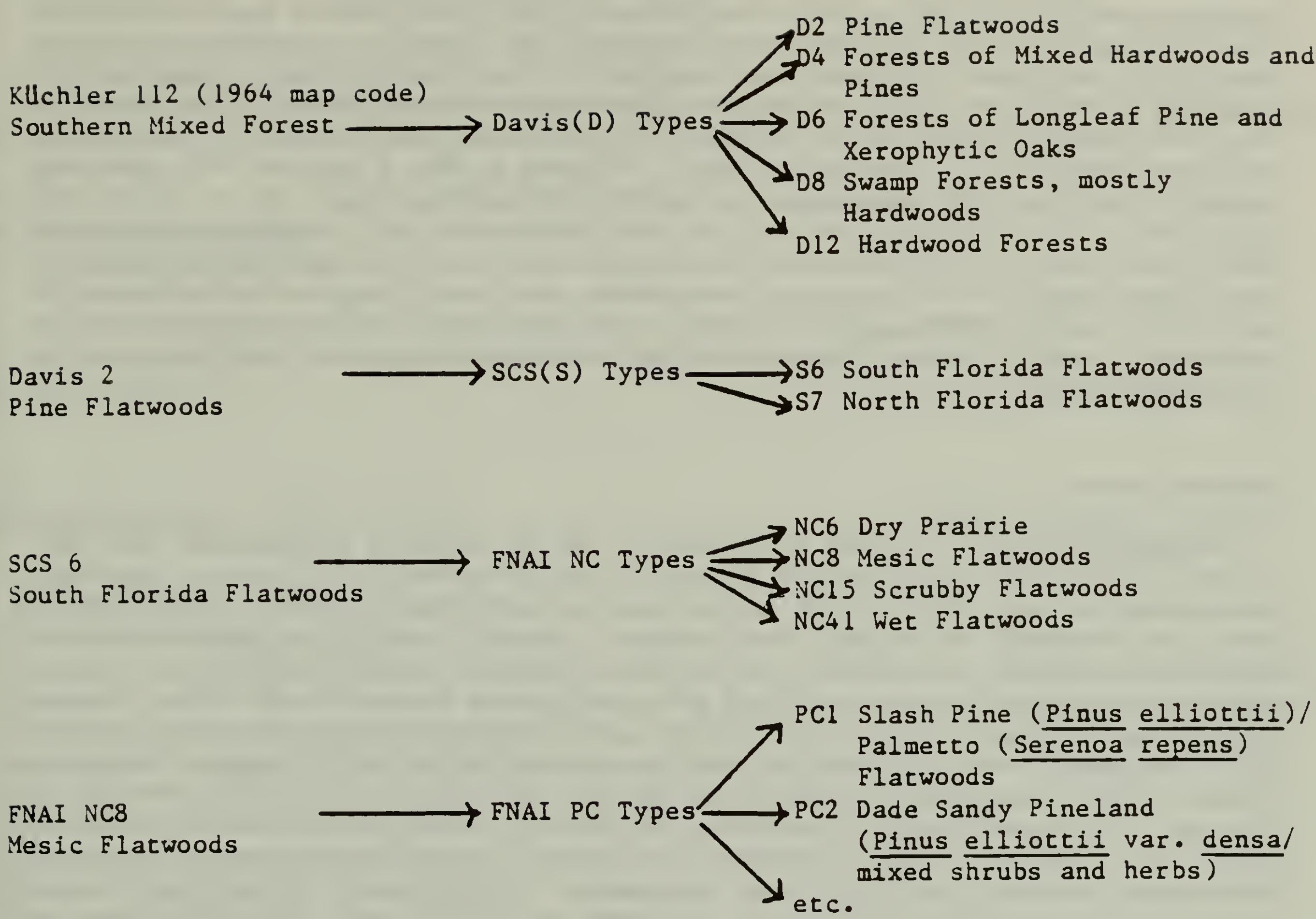

Figure 1. An incomplete hierarchial example of the diversity contained in an especially heterogeneous Kuchler PNV type, Southern Mixed Forest (*Fagus-Liquidambar-Magnolia-Pinus-Quercus*) in Florida. Davis types are from the General Map of Ecological Communities, State of Florida (Davis 1967). SCS types are from the General map of Ecological Communities, State of Florida (U.S. Department of Agriculture, Soil Conservation Service, 1980). FNAI NC and PC types are from the Florida Natural Areas Inventory list of natural communities (1985) and plant communities (1983), respectively. NC and PC type numbers were assigned by the authors.

completed for Florida. A conservative assumption of 3 FNAI plant communities per FNAI natural community yields an estimate of at least 45 identifiable plant associations in the Southern Mixed Forest type. In comparison, Sand Pine Scrub is one of the most homogeneous Kuchler PNV types in Florida, yet it contains at least 5 plant associations (Fig. 2). Note that Slash Pine/Palmetto Flatwoods (Fig. 1) could be considered as a climax association maintained by recurrent wildfires in the Pine Flatwoods component of Southern Mixed Forest. This contrasts with the Mature Scrub Hammock association of Sand Pine Scrub, which could be considered a postclimax type produced by an unusual, prolonged absence of a catastrophic fire. The point is that a Kuchler PNV type may consist of several plant associations in various successional stages, all of which need protection, if the Kuchler type is to be well represented in a macroreserve system. Ideally, this type of protection can be accomplished by preserving the Kuchler type in an area large enough for all important components and seral stages to be maintained in patches by random disturbances. In reality, some components and stages may have to be protected in small, isolated reserves and maintained by management practices such as prescribed burning.

Regionalization

Regionalization is a process often used in natural resource management that subdivides a piece of land, on the basis of one or more factors such as climate, physiography and vegetation, into several more homogeneous subunits (Bailey, Pfister and Henderson 1978). Each subunit or "region" then becomes a unique piece of the landscape with a specific geographical designation. For example, Fenneman (1928) subdivided the United States into 25 physiographic provinces with designations such as Great Plains, Central Lowland, and Appalachian Plateaus. Regionalization provides a useful means for reducing the heterogeneity associated with a major ecosystem like Kuchler's Northern Floodplain Forest. Widely separated occurrences of this type are found on Kuchler's 1964 map in Montana and eastern Kansas. These sites are located, respectively, in Fenneman's Great Plains and Central Lowland provinces. It seems reasonable to assume that such occurrences represent rather different ecosystems. This rationale was used by Davis in the U.S. Forest Service's 1978 survey of possible wilderness areas (U.S. Department of Agriculture, Forest Service, 1978) to convert 124 U.S. Kuchler PNV types into 242, and subsequently 233 (Davis 1984) ecosystems, based on the occurrence of substantial portions of some Kuchler types in separate Bailey ecoregion provinces (Bailey 1976, 1978). Crumpacker (1979, 1985b) used the same method, but with less rigorous criteria for subdividing Kuchler types, to identify 313 major ecosystems in the United States.

Database Contents

The national ecosystem conservation database will contain four main computerized parts (Crumpacker 1987): maps of potential ecosystem and macroreserve boundaries; cross-reference tables that relate ecosystems in one kind of classification to those in another; site-specific inventories which describe the ecosystems that actually occur on individual macroreserves; and a rating system for assessing the amount of protection expected in different kinds of macroreserves, as indicated by their management objectives.

The computerized map part of the database currently includes various national themes and several Florida themes that are being used in an individual-state pilot study. The

Küchler 115 (1964 map code) → Davis (D) Type → D5 Sand Pine, Pinus clausa, Scrub Forests
Sand Pine Scrub

Davis 5 → SCS (S) Type → S3 Sand Pine Scrub
Sand Pine, Pinus clausa,
Scrub Forests

SCS 3 → FNAI (NC) Types → NC14 Scrub
Sand Pine Scrub → NC23 Xeric Hammock

FNAI NC14 Scrub - FNAI PC Types

PC3 Sand Pine Scrub (Scrub forest dominated by *Pinus clausa*)

PC4 Rosemary Scrub (Open scrub with scattered shrubs and herbs, dominated by *Ceratiola eriocoides*)

PC5 Oak Scrub (Shrubby scrub dominated by *Quercus geminata*, and/or *Q. chapmanii*, *Q. inopina* and *Q. myrtifolia*)

PC6 Palmetto Scrub (Shrubby scrub dominated by *Serenoa repens*)

FNAI NC23 Xeric Hammock - FNAI PC Types

PC7 Mature Scrub Hammock (Scrubby low canopied xeric forest dominated by *Quercus geminata* and *Lyonia ferruginea*)

Figure 2. A complete hierarchial example of the diversity contained in a relatively homogeneous Kuchler PNV type, Sand Pine Scrub (*Pinus–Quercus*). FNAI NC – FNAI PC relationships were obtained from a combination of information in the Florida Natural Areas Inventory list of natural communities (1985) and plant communities (1983), respectively, and the Florida Natural Areas Inventory Community Element Abstract for Scrub (1984); these relationships are very tentative, since successional patterns are poorly understood. See legend to Fig. 1 for additional explanation.

themes are as follows: Kuchler's 1964 PNV map of the conterminous 48 U.S. states, modified to include an additional PNV type from Kuchler's 1966 map of the same states; the U.S. Department of Agriculture, Forest Service's 1978 RARE II B map of the 50 U.S. states, in particular the Kuchler PNV types for Alaska and Hawaii and Bailey's 1976 ecoregion province boundaries modified by G. D. Davis to fit the PNV boundaries wherever feasible over all 50 states; Bailey's 1976 map of U.S. ecoregion sections and provinces; natural regions recognized by the National Park Service (a modified version of Fenneman's 1928 U.S. physiographic divisions and provinces--U.S. Department of the Interior, National Park Service, 1972); the U.S. Department of the Interior, Geological Survey's 1985 map of ecological research areas, showing Udvardy's biogeographical provinces in the United States and the point locations of all U.S. biosphere reserves, national environmental research parks, experimental forests and ranges, experimental ecological reserves, and research natural areas; the National Geographic Society's 1982 map of "American Federal Lands" which includes the boundaries of 602 federal and Indian macroreserves managed by 8 federal agencies and various Indian tribes, plus the Bureau of Land Management's public lands; Davis's 1967 map of the natural vegetation of Florida; the U.S. Department of Agriculture, Soil Conservation Service's 1980 map of ecological communities in Florida; and the Florida Division of Recreation and Parks' 1986 map of the Florida State Park System. Maps have been obtained for most of the 87 federal, state, local, and private macroreserves in Florida and plans have been made to computerize them.

Cross-reference tables that relate ecosystems in different types of classifications are needed to determine how well a major ecosystem such as a Kuchler or Davis type is actually represented by various subtypes in the inventory of a macroreserve. Tables being developed for Florida are Kuchler-Davis, Davis-SCS (Soil Conservation Service), SCS-FNAI NC (Florida Natural Areas Inventory Natural Communities), and FNAI NC - FNAI PC (Florida Natural Areas Inventory Plant Communities) (see Fig. 1 and earlier discussion). Since this sequence of tables is largely hierarchical, additional pairs such as Kuchler-FNAI PC can also be cross-referenced, once the main sequence is specified. Other tables such as Kuchler-SAF (Society of American Foresters forest cover types; Burns 1984) will be added as needed.

Site-specific inventories are required to determine if potential ecosystems identified by preliminary map analysis as occurring in a particular macroreserve are actually there. Information of this kind has been obtained for almost all of the 87 Florida macroreserves and has already been computerized for most of the 28 federal ones. Each macroreserve computer file is organized as shown in Table 1. The "Special Conservation Subunits" section provides information on any 2,000 ha or larger, specialized conservation unit, such as a wilderness area or research natural area, that lies within the boundaries of the macroreserve. For example, there are 8 such national wilderness areas in Florida, of which 5 are in national forests, 2 in national wildlife refuges, and 1 in a national park. "IUCN/CNPPA Management Category" refers to 10 kinds of protected areas recognized by the International Union for Conservation of Nature and Natural Resources (IUCN's Commission on National Parks and Protected Areas, 1984). The section on "Ecosystem Types, Acreages and Descriptions" is extensive for some macroreserves. The format is designed to make the database compatible with the data storage activities of the IUCN Conservation Monitoring Centre in the United Kingdom (Harrison 1985; Harrison, Karpowicz and Green 1986) and the new Smithsonian Institution/Man and the Biosphere Biological Diversity Program in Washington, D.C. (Erwin and Gomez-Dallmeier 1987).

Table 1. Organization of information in a macroreserve computer file of the national ecosystem conservation database.

Major Macroreserve Information Categories

Name:

Ownership/Management:

Address:

Manager:

Key Contact:

Size:

Special Conservation Subunits:

IUCN/CNPPA Management Category:

General Location:

Udvardy Biogeographical Province:

Ecosystem Types, Acreages, and Descriptions:
Note: Classification system

Ecosystem Maps:

Manual File: Located at Florida Natural Areas Inventory Office, 254 E. 6th Ave., Tallahassee, FL 32303, phone (904) 224-8207

Last General Update of Information:

A computerized rating system based on macroreserve management objectives will assign protection values to each macroreserve (Crumpacker 1985a). Information to be used in developing the rating system for Florida has been obtained in cooperation with the Yale School of Forestry and Environmental Studies.

The mapping and graphics system used to computerize ecosystem and macroreserve maps was developed in the Florida Resources and Environmental Analysis Center at Florida State University. It includes a digital VAX 11/780 minicomputer supported by the Intergraph Corporation, a Control Data Corporation CYBER 760 mainframe computer, and the software needed to combine these units and access them for purposes of map overlay/production, and data generation/analysis.

Database Use

General Example

The general steps involved in utilizing the national ecosystem conservation database to assess the adequacy of ecosystem protection in a macroreserve system are as follows:

1. Use the cartographic part of the database to determine the amount of major diversity for potential natural ecosystems (e.g., as indicated by PNV types) that is present in the macroreserve system. This involves the overlay of major potential ecosystem and macroreserve maps and identification of the resultant gaps. Potential ecosystems found not to occur in substantial amounts within the boundaries of any macroreserve are then assumed to be inadequately protected in reasonably large occurrences of existing ecosystems. Potential ecosystems which do occur in substantial amounts in one or more macroreserves may be adequately protected by existing ecosystems. This is determined by analyzing each of these potential ecosystems further, as explained in steps 2 and 3.

2. Assume, e.g., that a certain major potential ecosystem occurs in only two parts of a macroreserve system, a national wildlife refuge and a state forest. Use the site-specific inventories for each of these two macroreserves and the appropriate cross-reference tables to determine how adequately the major potential ecosystem is represented by the existing ecosystems in each macroreserve. Amount, successional status, and condition of each existing ecosystem should be considered in addition to how representative it is of the major potential ecosystem type or a component of that type.

3. Use the protection rating system to estimate the level of future protection that each of the two macroreserves will provide for its existing ecosystems, assuming no change in management objectives. This will determine the future protection which the present macroreserve system can be expected to provide for the major potential ecosystem.

4. Considering the information obtained from steps 1, 2, and 3, make an overall assessment of the protection provided by the macroreserve system for <u>each</u> of the major potential ecosystems under investigation.

Some Possible Applications

Three hypothetical examples will illustrate a few of the many ways in which the national ecosystem conservation database might be used. Assume first that the Florida Division of Recreation and Parks wants to analyze the degree to which representative samples of 22 ecosystems, based on a combination of Davis natural vegetation and SCS ecological community types, are found in its macroreserve system. The Florida part of the database is used to prioritize each ecosystem according to its degree of representation, not only in the State Parks System but also in the state's macroreserve system (all state-owned or managed macroreserves) and in the overall macroreserve system of the state (all publicly or privately owned or managed macroreserves in Florida). The highest priority for future protection in the State Park System might then be assigned by the Division to those ecosystems not represented in the overall macroreserve system of the state.

An application to the management of a particular wildlife species might be as follows. Assume that a certain endangered bird species in Florida is adapted to hardwood swamp forests which currently exist as a fragmented habitat. Using the Florida part of the database, a map is produced that shows the location of all Florida macroreserves which contain actual samples of hardwood swamp forest. This is the existing macroreserve system for the species. A second map is produced, showing the location of all potential hardwood swamp forest (i.e., the combined Davis–SCS map of Florida with all ecosystems deleted except hardwood swamp forest). This is the potential preserve system for the species. The two maps are then compared in order to identify which locations of potential hardwood swamp forest might produce the greatest benefit for the endangered species, when added to the existing macroreserve system. The prospective sites could then be visited to determine the nature of any hardwood swamp forest they contain and the problems involved in providing protection for them.

A third example involves the design of a multiple-site ("cluster") biosphere reserve. Biosphere reserves form an international network of reserves intended to conserve the diversity and integrity of representative natural ecosystems in each of the world's major biogeographical provinces, as depicted by Udvardy (1984). They furnish areas for baseline environmental studies and research, and offer educational and demonstrational opportunities. A biosphere reserve should include the greatest possible diversity that is representative of the ecosystems in its biogeographical province. It is sometimes necessary to link several geographically separate sites together to achieve this goal (Fernald, Armentano, Gregg, Radford, Sharitz and Wharton 1983). For example, a multiple-site biosphere reserve would most likely be needed to represent the 14 Davis-SCS ecosystems found in the Everglades Biogeographical Province in southern Florida. The Florida part of the national ecosystem conservation database could be used to identify those publicly and privately owned macroreserves in southern Florida that are most suitable for this purpose. In fact, it was this and related applications in selecting and evaluating potential biosphere reserves that provided the initial incentive for developing the ecosystem conservation database.

Current Uses of the Database

The database is now being used to obtain preliminary estimates of the extent to which major terrestrial and wetland ecosystems are represented in the federal and Indian lands of the United States. Estimates will be produced for three kinds of ecosystems: (1) 135

Kuchler PNV types obtained from a combination of the 1964 Kuchler and 1978 RARE II B maps, (2) 250 to 300 ecosystems obtained by recognizing as additional, separate ecosystems some Kuchler PNV types that occur in different Bailey ecoregion provinces, and (3) approximately 350 ecosystems obtained by recognizing as additional ecosystems some Kuchler PNV types that occur in different National Park Service natural regions. These analyses consider only potential ecosystem diversity and are based on relatively small map scales ranging from 1:3,168,000 for Kuchler's 1964 map to 1:7,500,000 for the Alaska and Hawaii parts of the RARE II B map. The first analysis is completed (Crumpacker, Hodge, Friedley and Gregg 1987). At the map scales used in this analysis, large gaps are indicated in the ecosystem coverage of all federal land management agencies and Indian reservations. At least 33 of the 135 Kuchler PNV types are represented in relatively very small amounts in the federal and Indian lands as a group and 9 appear to have no representation. Considering that several component ecosystems are expected in an average Kuchler type, a large amount of U.S. ecosystem diversity appears to be inadequately protected at the federal macroreserve level. This is a conservative conclusion because some (perhaps much) of the "adequate" protection based on analyses of potential diversity will undoubtedly be found inadequate by further, more detailed assessments of the existing diversity in federal and Indian macroreserves.

Inaccuracies due to small map scales and lack of information on existing diversity in the preliminary national surveys, as well as restriction of the surveys to a less than comprehensive inventory of federal and Indian macroreserves, will be resolved incrementally through analyses of individual states. The Florida pilot study is the first of these. Its terrestrial and wetland parts should be completed in 1988. The speed with which the database can be extended to other states will depend on the amount of support that can be obtained to computerize their ecosystem and macroreserve map data. Once this is accomplished for a state, the map overlays can be done at a central data processing facility that has the appropriate technical capabilities. The "individual-cell" data produced by this process will consist of unique combinations of different data themes that characterize each specific, small part of the landscape; e.g., a certain map location in Florida may represent a particular biogeographical province, ecoregion province, Kuchler PNV type, Davis natural vegetation type, SCS ecological community type, and macroreserve (or no macroreserve). These basic data can be put on a magnetic tape and returned to the state, along with a software package for accessing and analyzing them on a personal computer. The state's biological resource specialists can then perform many analyses on the data, including the kinds discussed in this report, without having an elaborate, automated capability for cartographic analysis.

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EVOLUTION OF THE BIOSPHERE RESERVE CONCEPT[1]

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ABSTRACT. The "Mexican modality" of a biosphere reserve, originated and developed in Mapimi and La Michilia, Durango, Mexico, establishes conditions for making it possible to combine the usual activities in a biosphere reserve with two new ones: the participation of local people and research for regional development. Local participation poses new problems: (a) What can the local people expect from the biosphere reserve and vice versa? (b) To what extent is the local participation desirable in decision-making and in establishing new policies? (c) In what area or zone can certain activities be carried out? The two last questions are equally important when referred to research for regional development. New problems arise when biosphere reserves acquire their own characteristics, different from those of any other protected area. Finding a solution to these problems is the only way to guarantee the survival of an important part of the intertropical germplasm.

KEY WORDS: Biosphere reserves, conservation, Mexico, local participation, UNESCO-MAB program, regional development, germplasm.

The concept of biosphere reserves is undergoing a process of evolution which has become very evident in the last four years. Although UNESCO has carried out some important meetings for the discussion of different criteria, both the broadening of the original concepts and the implementation of operational and practical aspects have developed in what we could call the "periphery," that is, in some reserves that have approached and achieved new solutions.

This paper centers its objectives in only some of these aspects. We do not deal with other aspects, such as basic research or education; neither do we deal with environmental monitoring, which has acquired increasing importance in the Soviet Union (Izrael and Sokolov 1981; Sokolov 1985). Readers can obtain an updated global view of biosphere reserves in von Droste and Gregg (1985), Gregg (1984) or Maldague (1984); in documents such as MAB Number 58 (UNESCO 1985) or in "The Action Plan for Biosphere Reserves" (UNESCO, 1984 and 1985), and very specially in the two volumes of the book "Conservation, Science and Society" (UNESCO-UNEP 1984). This article deals

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[1] This article is a modified version of a more ample paper written in Spanish by Gonzalo Halffter, and published in G. Halffter, "Conservacion del patrimonio natural," Instituto de Ecologia (Mexico) Publications, 1987.

with what we consider the two more innovative aspects of biosphere reserves that are influencing conservation policies in many countries. We refer to the participation of the local populations and to research for development within biosphere reserves.

At this time, a conceptual analysis on biosphere reserves is necessary. Although numerous publications have appeared during recent years, many aspects of the biosphere reserve concept are still a subject of debate. Furthermore, some features-both general and referring to concrete situations--have shown the existence of new and as yet unforseen problems during their implementation. Local participation and research for development are included within this group. On the other hand, it is clear that the traditional concept of conservation, in order to be useful, has to be revised, if not in every country, at least in many.

Historical Development

The first biosphere reserves were established in 1976. By December 1987, there were 266 biosphere reserves distributed in 70 countries. During the first years, the main worry of the program's promoters was to create reserves in order to make the idea both feasible and visible. A few of those initially involved in the program, later followed by a growing number of people, have insisted since 1981 on the need for changing a quantitative process into a qualitative one, taking advantage of the experiences generated in the reserves which function adequately and innovatively, but also taking into account the failures and frustrations harvested in other places.

There are some important events in the evolution of the biosphere reserve criteria. In 1974, UNESCO published Report 22 defining a biosphere reserve and pointing out the objectives of the program. In 1981, a very important meeting called "Ecology in Practice" took place in Paris to celebrate the Tenth Anniversary of the MAB-UNESCO Program. During this meeting the importance of biosphere reserves became evident. A total of 208 biosphere reserves existed at that time. It was also evident that many were merely national or natural parks to which the designation had been applied without adding new land or new functions. In some other cases new functions had been added, or even land. But what was really important was the existence of some reserves making an effort to carry out the objectives that MAB had pointed out, including new experiences related to local participation and research for development (Lusigi 1981; Lusigi and Robertson 1981; Halffter 1978, 1980, 1981; Halffter et al. 1980). A compendium of the presentations at this meeting (di Castri, Baker and Hadley, 1984) provides an idea of the successes of the program, but also the very different criteria and practices within the program.

The international discussion that started in 1981 was much clarified at an International Congress on biosphere reserves held in Minsk in 1983. In this second great international meeting, elements such as local participation and research for development were discussed in detail and had to be admitted as important biosphere reserve functions, even by the most uncompromising. The importance of the Minsk Congress can only be appreciated by the examination of the rich material found in the two volumes of *Conservation, Science and Society* (UNESCO-UNEP 1984), which gathers the papers presented and provides the basic reference on the present situation of biosphere reserves.

The ideas discussed in Minsk were the basis for the Action Plan adopted by the MAB-UNESCO International Coordinating Council in December 1984. This plan constitutes the second international document on the development of biosphere reserves. It substitutes and partly modulates (rather than modifies) the first document prepared in 1974.

It is a plan that contemplates the development of biosphere reserves as an international network and presents thirty-five actions grouped under nine main objectives. The plan has received wide distribution (UNESCO 1984 and 1985) and has been submitted to governments, national MAB Committees, international agencies, etc. It coordinates the actions of MAB-UNESCO as an international organism and it deserves full consideration, and if possible, adoption by MAB national committees.

At the same meeting of the International Council, two high-level international, independent scientific groups were authorized. The first one was created to examine MAB's scientific policies, the other to study the situation of biosphere reserves and propose steps to begin implementing the Action Plan. The second group met in Cancun, Mexico, in September 1985, and later in La Paz, Bolivia, in August 1986. A document that synthesized the opinions of this group was presented to the International Coordinating Council in October 1986.

Gonzalo Halffter, as President of the International Coordinating Council, received the mandate to coordinate the advisory scientific groups' activities in light of the general feeling that the situation is different from 1971 when MAB was started. It is different with respect to scientific concepts and the vastly increased level of knowledge. There has been a truly major change in the orientation of ecological research. The scale and magnitude of the problems have increased. We are facing the effects of human activity whose intensity and velocity are different from what we thought they were sixteen years ago.

Discussion: Conservation

The objectives established by the MAB-22 report for biosphere reserves are:

(a) To preserve for present and future use the diversity and integrity of biotic communities within natural and semi-natural systems, and to safeguard the genetic diversity of species on which their continuing evolution depend;

(b) To provide areas for ecological and environmental research, including baseline studies; and

(c) To provide facilities for education and training.

In 1981, with the biophere reserve program in full development, the main emphasis was on conservation, combined with research, environmental monitoring, education and training (UNESCO 1981). Research for development and local participation were not widely promoted, although they had been important activities in several reserves since 1975. As the biosphere reserve concept evolved from the limited definition of a protected area to the more dynamic one of a multifunctional unit in which the relationships between man and nature are studied, the need to combine several functions in one large unit arose, as well as the need to join these large units in an international network.

The widening of objectivesand the associated recognition of the need for development-related research and local participation must not mask the fact that the main and prior purpose of biosphere reserves is the protection of natural areas and their genetic diversity. When we refer to areas that have to be conserved and protected, we do not mean only climax formations, but also those man-modified landscapes where traditional use has maintained or even increased ecological and genetic heterogeneity, which can be endangered by a production-oriented mode of development.

The compatible integration of the different functions of a biosphere reserve is frequently a rather complex problem. The main difference between individual reserves, as well as between the systems of different countries, lies in the relative importance given to these different functions.

The coexistence of conservation with other functions is easier if the reserves have a functional transition area between the core area and the outside--not only because transition areas contain the space where manipulative research can be carried out without interfering with conservation, and not only because they protect the core areas from the impacts of the outside world, but also for a third and seldom discussed reason. Transition areas, especially where cooperation is actively pursued, seem in many cases to be the only way of enlarging (with all the precautions, criticisms and extra efforts that this may imply) the available space for conserving plants and animals. [2]

As time passes, the space problem appears to be increasingly the main limitation to conserving the biotic richness of the vast majority of ecosystems. It seems impossible to base conservation only on core areas or on other systems of completely protected areas. Dasmann (1984) clearly points out:

> "All reserves must ultimately depend on the good management of the lands outside the reserve boundaries, and on an attitude of people toward the more mobile animal species . . ."

It is evident that conservation, in many cases, requires more than a strict "do not touch" model. The managers of North American parks long ago discovered the necessity of monitoring and managing the larger animal populations. As the biosphere reserve idea has extended into different countries, it has been noted that the concept can include certain management practices on the native populations to help preserve species diversity, like the breeding of traditional crops and animal domesticates. This can be a cheap and efficient way of conserving a very valuable germplasm.

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[2] The reserves of Waterton, Canada (Scace and Martinka 1983; Lieff, 1985) and Mapimi, Mexico (Halffter 1981, Halffter et al. 1980) are excellent examples of how cooperation and local participation can foster conservation, even of the difficult species, and extend their habitat range.

The protection of animals dangerous to man (which, on the other hand, are often spectacular faunal elements) brings forth some very delicate problems as demographic pressures increase on the boundaries of the reserves. In countries where this pressure is not so strong and can therefore be controlled with administrative measures, some remarkable examples of recovery have been attained (for example, the tiger of Amur, in the east of the Soviet Union; see Zhivotchenko 1984). When the demographic pressure is strong, one of the most feasible possibilities is to enlist the understanding and collaboration of local populations (see Saharia 1984, in relation to the lion and the tiger in India; and Mishra 1984, in relation to tigers and rhinoceros in Nepal).

In these cases, approaches like Soule's (1984), stressing the advantages of few large areas instead of many small ones, are very important. From the point of view of the relation with local populations, it is also easier to manage large reserves than to manage many small ones.

The Action Plan (UNESCO 1984, 1985) is extremely broad in its criteria on how to combine conservation with other uses. On page 41 (French version, 1985), it points out that a reserve "Peut etre devrait-elle etre moins consideree comme une 'reserve' que comme une zone de paysages ecologiquement representatifs ou les modes d'utilisation sont reglementes, mais peuvent varier entre une protection totale et une exploitation intensive tout entant durable."

It is difficult to combine conservation with intensive exploitation, unless the latter is carried out in the transition zone or outside the limits of the reserve. On the other hand, intensive expoitation implies high economic yields. Biosphere reserves are not needed for this kind of activity. There is a great incompatibility between intensive exploitation to maximize economic profits and germplasm conservation, or between such exploitation and the maintenance of a continuing harmonious relationship between man and nature.

We consider that the only possibility of intensive use within a biosphere reserve is that carried out experimentally to serve as a model for the region where the reserve is found, and even in these cases it must clearly be a research-for-development project, limited in space and time.

Discussion: Local Participation

Originally, the conceptual base of biosphere reserves did not establish the participation of the local populations, nor did it discuss how the work carried out in the reserves can influence (besides the general effects of research on development) the local and regional economic situation. Other systems of protected areas, like national parks, completely exclude local populations. As Eidsvik (1984) points out, the measures taken in parks were not aimed towards the integration or the benefit of the local population, but towards protecting the park from people. Without any doubt, for nearly a hundred years most references to the conservation of nature for the people meant implicitly the urban population. In many of the first parks, conflicts arose from differences between the local populations and the creators and managers of the parks in relation to race, culture and economic stratus. As Walter Lusigi (Lusigi 1981, 1984; Lusigi and Robertson 1981) has pointed out, the first step taken was to expel the local inhabitants from the park area. Conceptually, this situation has changed and the problem now being addressed (see papers in McNeely and Miller 1984, as well as Eidsvik 1984; Batisse 1984; and the Action Plan).

From the beginning of the biosphere reserve program, even before the reserves were formally designated, there were three cases in which it was demonstrated that local participation was not only possible but even convenient and necessary. We are referring to the Mount Kulal Reserve in Kenya, and to the Mapimi and La Michilia Reserves in Durango, Mexico (see references in the bibliography under Lusigi and Halffter). Although these three reserves were established in underdeveloped countries where conditions are difficult, at present the most successful examples are found in rich and industrialized countries. Actually, although not without problems and efforts, the conservation authorities are quickly appreciating that local populations can be part of protected areas and can provide important help in germplasm conservation. In the case of some crops and domesticated and semi-domesticated animals, traditional use by local populations is the best way to assure their conservation. The participation of the population and of the local and regional institutions can be important elements in critical--but not impossible--circumstances, in which the central authorities lose interest or do not have the means to continue with a reserve. Finally, the expansion of the core area into the cooperation zone is a possible response to the great problem of lack of space to which we have referred before.

The successful inclusion of local participation in biosphere reserves raises new questions: (a) What can the reserve expect from the local populations and vice versa? (b) To what extent can local populations make decisions, especially when these concern research and conservation? (c) Which actions are desirable and which are not? And a fundamental and critical point: (d) In which areas or zones can a certain action be carried out and in which not, since its implementation could affect or could be contradictory with other reserve priorities? Some of these questions are partly answered when analyzing the following examples.

The Mexican Modality

Mapimi and La Michilia, in the State of Durango, Mexico, are not only successful biosphere reserves but also the places where, since 1975, the "Mexican modality" of biosphere reserves has been started and improved (see Halffter et al. 1980; Halffter 1984b, 1984c).

According to this "modality," the integration of local people in the activities and programs of each reserve has a dual objective. First, it contributes to developing alternatives that will allow a better living standard for the traditionally marginated peasants of the economically disadvantaged areas. The second objective is directly linked to germplasm conservation: Only by trying to involve the local people and by helping them to solve their most urgent problems, can we assure the long-term stability of the reserve. A reserve that is found in a region of strong demographic pressure or where peasants do not own the land is continually exposed to invasions. There are no legal rules which can prevent by themselves, in the long-term, the penetration of the protected area and the resulting deterioration of flora and fauna. For a hungry peasant, the only possible solution to conservation is to help him produce what he needs without destroying the natural richness that belongs to all. Halffter has presented this idea many times (see references), but the important fact is that it has been followed in the two Mexican reserves of Mapimi and La Michilia.

In Mapimi and La Michilia, nothing is done if it has not before been discussed with the local authorities and with the regional and local people. The beginning of the work in La Michilia was thoroughly explained to the communitary organization or "ejido" of San Juan de Michis, a village found in the periphery of the reserve. We were there for two days explaining the objectives to the peasants and we offered them collaboration. The resulting agreement was submitted to popular suffrage. La Michilia started to work with a vote of support "for progress."

The relationship with intra-reserve or peri-reserve communities requires time and effort, and it can prove to be impossible if the different levels of social organization and regional politics are not taken into account (from municipal presidents to state governors, without forgetting the "ejidos," cattle-raising associations and similar groups). A fundamental part of this social pact are the schools, with emphasis on the universities and high schools of the region. The staff in Mapimi and La Michilia has made a great effort towards the popularization of conservationist ideas, aimed towards this local and regional public. Other measures have also had good results. For example, all the work carried out in the reserves has been done by people of the region, from the architect that planned and constructed the laboratories and residences to the field workers and managers who belong to families living within the reserves or in the surroundings. Moreover, the reserve facilities (and the Institute of Ecology, which manages the reserves) have always been open to help if there is any local requirement, from medical emergencies to the implementation of environmentally appropriate development and social welfare projects.

For those who have not lived the experience, it is difficult to understand what the well constructed Desert Laboratory with its constant presence of scientists, 40 km away from the nearest village in the desert and 3 or 4 hours by car from a city, represents for local people in the Mapimi Reserve. The Laboratory has electricity, a good landing field for airplanes and helicopters, antitoxin serum for snake bites, radio communications; and a manager, assistants, and scientific personnel living in the Laboratory. Within a desolated and difficult habitat, it is a place where everybody is welcome.

It is most important that the local population and the region in general take a direct and immediate interest in the research carried out in the reserve, and many of the research activities have, in fact, been locally and regionally requested.

What we understand by "local population" needs to be stated precisely, since the term has several possible interpretations. Undoubtedly the term means more than the very few families of cattle raisers (Mapimi) or peasants (Michilia) who really live within the reserve. It includes populations on the periphery of the reserve and in the cooperation zone. Actually, it includes any population nucleus which is near and can feel, or be affected by, the actions of the reserve, and at the same time can be able to affect positively or negatively conservation or scientific work through its activities and way of life. But the interaction also involves private associations (as associations of cattle raisers, "ejidos," etc.), political organizations (municipal presidents and especially state authorities), and regional, educational and research centres.

In every reserve that subsequently has been or is being established in Mexico following the ones in Durango, the Governor and the authorities in charge of the environment and of the development of the state, as well as state universities and research centres, have been in charge of coordinating and promoting the project. In other words, the reserves have been built *in situ*, even though they have received great financial and political support from the Consejo Nacional de Ciencia y Tecnologia (National Council of Science and Technology) and from MAB–Mexico. They have never been imposed by the central government.

There is a case in Mexico in which these goals have not been fulfilled, or have been only half fulfilled. This is the case of the Montes Azules Reserve, in the Selva Lacandona, in the State of Chiapas, bordering Guatemala. Though it has to be admitted that this reserve faces unexpected and strong social pressures (an immigrant population which is partly foreign and is difficult to control), the truth is that it has also received important financial support. Perhaps because the "Mexican modality" was not followed, this reserve has not been consolidated as Mapimi or La Michilia; neither does it offer the possibilities of the other three recently created reserves (Sian Ka'an, El Cielo and Manantlan).

The "Mexican modality" is based on the following points (Halffter 1984a, b):

1. The incorporation of local people and institutions to the common task of germplasm conservation.

2. The incorporation of the regional socioeconomic problems into the research and development work at the reserve.

3. To give the reserves administrative independence by commissioning their management to research institutions that respond to the higher (state and federal) authorities of the country.

4. To consider the reserves (and also the parks) as a part of a global strategy.

The third point is not necessarily valid for every country, especially those which have well established park and reserve management systems. We believe it can be very useful in underdeveloped countries, and also in some developed ones where the park system is not very efficient or where it functions according to obsolete rules. The other three points are of universal application, and can give, for the next fifteen years, a new perspective to biosphere reserves.

Let us examine how the "Mexican modality" has influenced one of the three recently created reserves: the Sian Ka'an Reserve, in the State of Quintana Roo, Mexico, on the Caribbean shore of the Yucatan Peninsula. Sian Ka'an includes 528,000 ha. One third of it is forest; another third is floodlands and mangrove swamps; the rest of it, marine environments. It includes at least twelve different vegetation types, with 1200 vascular plant species and an approximate total of 320 bird species.

The area to be protected by the Sian Ka'an Reserve has been kept exceptionally undamaged. For historical reasons, Quintana Roo (except the Island of Cozumel) has been kept isolated from Yucatan and from the rest of Mexico. Tourist development started only 15 years ago. Livestock development is even more recent. Disturbances have not yet reached Sian Ka'an.

Together with conservation, Sian Ka'an puts special emphasis on research. The reserve provides exceptional opportunities for studying the relationship between socioeconomic and cultural factors and natural resources, because the rich traditional Mayan use of the flora in the reserve and its periphery, as well as traditional Mayan agriculture, are still practiced. The reserve tries not to lose this efficient silvoagricultural system. The cooperation of the local and peripheral population is indispensable to success in the conservation of the Mayans' traditional land use, as well as in developing socioeconomic research.

Eight hundred persons live within the reserve at present. Twelve families practice the traditional Mayan land use, which is being actively encouraged. The rest are involved in lobster fishing, an activity that is already receiving technical support. The challenge is to stabilize resource uses within the reserve with the participation of local people. Later on, the aim will be to influence the surrounding populations outside the reserve in the same way.

Most of the area is federal property. Only one percent is privately-owned land, located along a chain of beautiful beaches. A coastal zone will be established along this fringe, in which "soft" touristic development will be allowed, based on an ecological regulation that has been well received by the owners. The Management Plan establishes a precise scientifically-based zonation with large core areas devoted to integral conservation, as well as gathering areas in which game and gathering will be allowed for the people living within the reserve, farming areas in which Mayan land use practices will continue, and an archaeological-touristic zone. There is no access to the core areas, nor is any planned.

The reserve has been created by presidential decree. The "Secretaria de Desarrollo Urbano y Ecologia" (federal agency responsible for protected areas) and the Government of Quintana Roo supervise the reserve management. The CIQRO's (Centro de Investigaciones de Quintana Roo's) Research Centre of Quintana Roo also plays an important role in the reserve's management. The Consejo Nacional de Ciencia y Tecnologia (National Council for Science and Technology), as in other Mexican reserves, supported the research that helped provide the basis for creation of the reserve. It supports projects such as faunal and floral inventories, basic research, and research for development. The local people have organized a forum in which they express their ideas through the Representative Council, created in 1983. A private association called "Amigos de Sian Ka'an" (Friends of Sian Ka'an) has been created by local residents and people from the state, as well as others from outside the state, interested in conserving the flora and fauna of the reserve.

The "Mexican modality" has already had international influence. Gilbert (1984: 567-568), for example, wrote that: "Two biosphere reserves, La Michilia and Mapimi in Durango, Mexico, illustrate how scientists, politicians, and local people can work together to improve the conservation of natural resources of a region and at the same time raise the economic and social standard of people living in and around the reserves . . . After visiting these biosphere reserves and observing at first hand the working relationship between the Mexican scientists and the local people, I suggested the Michilia as an example to authorities in Honduras considering establishing a biosphere reserve in the Platano River Region. The Rio Platano Biosphere Reserve was later created and a management programme which incorporates the local population in the protection and development of the area is being carried out . . ."

Rio Platano Reserve, Honduras

Like the Mexican reserves, Rio Platano was born as a biosphere reserve, not as a park, and with the same objectives as the "Mexican modality." Its creation was carried out by RENARE (Direccion de Recursos Renovables), an agency of the Honduran Government with experience in ecological development. Thus, local participation and appropriate development were included in its objectives from the beginning. The opinion of V. Gilbert, who visited Rio Platano during its first stages as a MAB-UNESCO expert (see Glick 1984), possibly contributed to this.

Cevennes National Park and Biosphere Reserve, France

This park was established in 1970 with two very particular features: (a) the presence of a human population inside the national park; and (b) the possibility for the permanent population to hunt in a restricted way (a unique situation in France's national parks).

The park-reserve includes three different ecosystems: (a) Les Causses, which are formed by limestone plateaus without surface waterways and have a harsh climate with very cold winters. At present, they are covered by a sparse grassland, pine-oak forests, and some planted pine forests. (b) The Granite massifs such as Mont Lozere, in which the natural vegetation is beech forest and, in the highest parts, a subalpine grassland; and (c) the Cevennes area, where chesnut forests grow on schists.

The park-reserve has been considerably modified by man, sometimes in harmony with nature, sometimes involving exploitation in excess of sustainable limits. Thus, the increasing sheep densities and the opening of some areas for agriculture in the eighteenth and nineteenth centuries reduced the forest cover in the higher elevations. This coincided with the intensive use of the beech forests for the production of charcoal. The overexploitation resulted in erosion that was subsequently corrected by replanting conifer forests. At present, all of the area, especially Les Causses and the granitic massifs, face an acute problem common to this region of the South of the Central Massif of France: land abandonment.

This situation contrasts sharply with the demographic pressures faced by the majority of the reserves; in fact, it may be almost unique. Here, the demographic pressure in the peripheral area poses no problems (the population of "Le Causse Mejean" in the park-reserve is the lowest of France: 1.5 habitants/km^2). On the contrary, the decrease in population is damaging a diversified landscape, which has been created and is maintained by human action. This situation demonstrates the importance of keeping the local population within the protected areas. The abandonment of land is a complex phenomenon that cannot be explained at only a local or microregional level. However, more general phenomena, like industrial and intensive high-yield agricultural development in the neighboring lower elevation areas, have undoubtedly had an influence, as well as the lack of demographic increase and urban migration. On the other hand, regional and sometimes local phenomena are also factors. The history of the region is one of equilibrium (sometimes lack of equilibrium) between the sheep flocks and the forest. The decrease of the sheep flocks is very marked at present. Being the only economic activity in Les Causses and in the higher parts of the granitic massiffs (partially substituted by cattle breeding at present), this crisis in the traditional herding has contributed to the population exodus. The decrease of sheep breeding is strongly linked to the disappearance of the trans-humance, a system in which hundreds of thousands of sheep were led to graze in the higher elevations during the first decades of this century.

Another socio-ecological problem is the practically complete disappearance of the chesnut tree industry. Years ago, the fruit of this tree was an important source of food for the "cevenol" and their flocks. The timber, firewood and tannin of this tree were also used. The marked decrease in the consumption of chesnuts led the local people to abandon the forests, where the chesnut tree is being substituted by other species. Cultural phenomena at a sub-regional level have also influenced the area in a very important manner. The white mulberry tree and the silkworm were cultivated in the Cevennes region. The silk was exported to Lyon or used in the manufacture of stockings in small villages such as Ganges. In Millau, the fine glove industry, made from lamb leather coming from Les Causses, was very important. However, silk stockings are no longer used nowadays, and the market for fine leather gloves has decreased substantially. All these factors should be kept in mind when considering the population decline from the one that existed at the end of the eighteenth century.

The decrease in the population of the park-reserve prompted three possible scenarios: (a) Extensive planting of pine plantations to produce wood pulp. This requires a small population with little profit for the area. (b) Increasing abandonment of economic activity, with a parallel increase in the successive stages of the climax forests. (c) Authorization of an aggressive tourism, such as hotel construction, ski trails, etc. Under each of the three alternatives, the agro-silvo-pastoral system (and all it represents for the equilibrium, beauty and heterogeneity of the landscape, as well as for the culture developed around it) is threatened (Collin, Durand-Gasselin and Joly, 1986; Chasanny 1986).

For all these reasons, the fundamental objective of the park-reserve is to preserve this system with the aid of research (for example, through testing and demonstration of fertilizing practices) to make the land more productive. Nevertheless, it is clear that the system cannot survive if the local people do not remain there.

Begue (1984: 536) points out: "The creation of a national park has provided a solution in that the park helps to promote a greater control of their area by the local people."

This control is obtained, according to Begue, by: (a) limiting land speculation activities (any new construction apart from the farms is avoided); (b) restricting outdoor camping; and (c) limiting the right to hunt to the local people. All these measures have been carried out with success. However, it is our opinion that the hunting pressure is still excessive; but this is a generalized problem in France, as the right to hunt was granted by the 1789 Revolution as a right of all citizens. With these measures, the establishment of massive tourism in the park, controlled from the outside (which would affect the natural and cultural landscape) has been avoided. Even more important, tourism integrated into the agro-pastoral way of life has been successfully developed and properly carried out, representing an important source of income for the local people in the park and peripheral areas.

All this highlights the great importance of involving the local population, as well as keeping them informed and aware of the problems inside the protected area.

Other Examples

There are other examples, although not many, of local participation, already working or getting underway. In the industrialized countries, the Waterton Biosphere Reserve of Canada (Cowley and Lieff 1984) and the Pinelands National Reserve of the United States (Hales 1984) are of the greatest interest. In this article, we have often made reference to the Mount Kulal Reserve in Kenya (Lusigi 1984). One of the purposes of India's proposed biosphere reserves is to incorporate local people into the legal structure and biosphere reserve program through environmentally appropriate development activities (Jayal and Lausche 1984; Khoshoo 1984).

The incorporation of local people can bring some problems, such as the possible conflict between short-term economic interests and ecological and genetic conservation. It can also bring antagonism between different land uses; for example, grazing by large sheep herds as opposed to the recuperation and adequate use of forests. When the intra-reserve population consists of too many groups with more than one economic activity, the conflicting activities may become evident and could endanger the continuity of the reserve itself.

A problem that has not been clearly discussed in our first papers on local participation and traditional uses is the possibility that the human activities may not be compatible with ecological or genetic conservation. Traditional uses are not always, nor necessarily, in equilibrium with the environment. The equilibrium may exist when the traditional uses have been practiced for a very long time and have not caused environmental deterioration. But in some cases traditional use does not reflect an harmonious man-nature equilibrium. In any case, ecological and sociological research will determine which actions are favorable to the environment and worthy of being preserved, and which are not. Undoubtedly, the involvement of local populations is one of the aspects that will vary most from nation to nation and from reserve to reserve, as the social, cultural, economic, legal and political conditions differ. What is really important is not to lose sight of the main principle of taking into account the people who live in the reserve or near it, and not to consider people as antagonistic to conservation.

The local participation and the research for development carried out in a reserve must have the characteristics of an experimental model. As a consequence, the good results as well as the bad ones must influence regional and even national policies because these results may be of interest to more than one region with similar economic and human problems. Only in this way will the reserve gain importance as an area where an harmonious, sustained, and integrated man-nature development can be demonstrated and recommendations made based on scientific research carried out under monitored natural and socioeconomic conditions, and often under experimental control.

Halffter (1984b) has pointed out that the great challenge nowadays for world conservation is not to open new parks, but to find answers with a solid ecological, social and economic basis to address the apparent dichotomy of protected areas versus regional development. A functional biosphere reserve must be more than just a conservation area. Without losing this character, its action and influence can go beyond its boundaries to contribute to a more rational use of biotic resources. Thus, the reserve becomes a pilot area where research, conservation and experimental development are combined.

The integration of conservation and basic research with research for development is one of the novel aspects of biosphere reserves. The work done in the Mount Kulal Biosphere Reserve, Kenya, is an excellent example of how this integration can be developed (Lusigi 1984). This reserve studies the relationship between nomadic grazing, biotic resources, and erosion (Project IPAL). The purpose is to establish guidelines for a harmonious use of water, land and biotic resources, with rules of usage that are compatible with the interests and habits of the local population.

Lindqvist (1984), McNeely (1984) and Eidsvik (1984) have made reference to the opportunity of integrating conservation and development in the biosphere reserves. Montana (1984), Ezcurra (1984), Ochoa-Solano (1981), Ochoa-Solano et al. (1978) and Halffter (1978, 1981, 1984a, b and c) have made reference to the actions carried out in the Reserves of Durango, Mapimi and La Michilia, and their integration to regional development as well as their relation to local necessities.

In the industrialized countries, the potential impact of research for development is significant, as in the Cevennes National Park and Biosphere Reserve. When research for development ceases to be a wishful intention and becomes a reality, a potential problem arises: the conflict between research for development and conservation, particularly when the results of the former start to be applied. The conflict is real when the core areas are small, or when the experimental research is carried out extensively and intensively in the buffer zone. There are two ways of reducing this confrontation: (a) The whole reserve must have a general plan of research and activities indicating what land use, in what zones, and up to what limits can be carried out. This plan is especially important in areas where experimental development may directly affect conservation. (b) In addition, the zonation of the reserve must be effective.

Zonification in biosphere reserves has existed since the idea was initially conceived. It becomes absolutely indispensable when research for development gains importance. It is essential to point out very precisely where certain development projects can be carried out without affecting the conservation programs. The solution to this problem has been approached in the United States, by integrating into one reserve several areas fulfilling different functions under different administrations (Gregg 1984a, 1984b). The California Coast Ranges Bisophere Reserve, for example, has three separate units, in which six different administrative agencies work. If there is a previous agreement and coordination among the different agencies, this system can combine research and experimental development with conservation, minimizing potential problems due to conflicting objectives.

Following the same idea, the Action Plan incorporated into the "buffer zone" concept (which already exists) the notion of "influence areas" or "cooperation areas."[3] These areas together form a "transition area" that links and separates the core area(s) from the outside.

The influence, or cooperation, zone is best suited to carry out research related to development, conservation of traditional land use and restoration of degraded ecosystems. This area does not necessarily have to be strictly delimited. Its existence is often due to local agreements, and possibilities for enlarging its sphere of activity must be continually pursued.

These zones ensure that the reserves do not become alienated from the region in which they are located. It is necessary to realize that while even in the best case an area protected in a biosphere reserve or other protected area system is progressively expanded, it will cover only a small percentage of the earth's surface and in many regions will still be wholly insufficient for effective conservation. The extinction of many taxa can best be avoided through sound management of the land outside the protected areas.

The most important contribution of biosphere reserves to long-term development is to make development as completely compatible as possible with the conservation of nature and of its biotic richness. In this aspect, the role of the reserve as a model for regional development is especially important, and this is also the main reason for maintaining local people within the cooperation zone of the reserve, since it is very difficult to promote a regional model of development without taking into account the regional human interests, habits and local traditions.

An interesting difference between developing and industrialized countries with long-established traditions in the conservation of nature, is that in the former (and also in developed countries where conservation is not a major public priority) it is difficult to ensure adequate protection so that the core areas may fully carry out their functions. In countries with well-established conservation systems, the protection of the core areas does not generally pose a great difficulty; often it is a park with a well-defined administrative and managerial structure. On the other hand, difficulties appear in the buffer or influence zones, where an overlap of functions and administrative agencies can occur with the resulting need for coordination and with the possibility of finding difficulties in attaining specific solutions (sce the solutions for Waterton Reserve in Scace and Martinka, 1983).

Synthesis

It is difficult for a reserve to fully carry out all the functions pointed out in the Action Plan. In the majority of cases, some functions will have priority. It is important, however, to pursue a variety of objectives. The simple search for a harmonious and diversified development is in itself of great value.

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[3] The use of this term apparently arose in the Waterton Biosphere Reserve, Canada (Lieff 1985).

If we had to give an absolutely up-to-date definition of what a biosphere reserve should be, we would first give two general ideas:

1. There exists a great variety of answers to what an ideal reserve is. This variety responds to different social, economic, ecological and historical conditions, and is in itself not undesirable. On the contrary, it is one of the best guarantees of stability and continuity of the system. Michel Batisse (1987) has appropriately pointed out that the key word for implementation of the Action Plan is still flexibility.

Nothing can be more unrealistic and ephemeral than the automatic implantation of a model no matter how well-conceived it might be. Every approach must be adapted to the socioeconomic reality and specific policies of each country. This leads us to conclude that in maintaining the basic objectives of biosphere reserves, there is not a unique approach but several, which may encompass important differences (Halffter 1984b).

2. Biosphere reserves are not the only alternatives for the conservation of nature and genetic resources. Other kinds of protected areas exist which have been adequately defined by IUCN. The best national program is one that includes a variety of alternatives, according to the specific necessities of each case and the purposes to be pursued (Halffter et al. 1980; Halffter 1981, 1984; McNeely 1984).

With these two ideas in mind, we could define a reserve as a large area of multiple uses, where zones with different levels of protection and with different management rules coexist, but where the whole system is managed by a coordinated plan that aims to achieve compatibility between the long-term conservation of a high diversity of plants and animals with research and experimental development.

One of the remarkable characteristics of biosphere reserves is to be part of an international system whose goal is to coordinate research and action. Research and conservation cannot be indifferent to regional socioeconomic problems. If part of the research does not deal directly with the problems of local inhabitants, the reserve is irrelevant for them. Without local cooperation, long-term conservation is not only more difficult, but may distort the primary objective of conservation for man.

In our time, the tremendous uniformity imposed by the ways of working and the uses and necessities of industrial society threaten as never before not only our natural but also our sociocultural richness and diversity. The biosphere reserves represent small islands of natural heterogeneity and diversified use of the natural resources; it is our responsibility to derive from them useful lessons of what to do with the rest of the Earth that is, and will be, outside of any protected system.

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BIOLOGICAL AND SOCIOECONOMIC IMPORTANCE OF THE SIERRA DE LA LAGUNA AT BAJA CALIFORNIA SUR, MEXICO

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ABSTRACT. A new biosphere reserve is proposed for the conservation of natural resources at the Sierra de La Laguna in Baja California Sur, Mexico. The low demographic density, its geographical isolation, its geological history and hydrographic features, the uniqueness of its flora and fauna, and the high incidence of endemic species and subspecies in almost all groups of plants and animals are presented. The principal research activities carried out in the region are also described, and several arguments are given in support of the conservation of this mountainous region.

KEY WORDS: Cape Region, biosphere reserve, geographic isolation, endemism, flora, fauna, Baja California Sur, Mexico.

Introduction

At present, the state of Baja California Sur, Mexico, represents a biological paradise and an ideal place for the establishment of a new biosphere reserve (Fig. 1). The low human population density and geographic isolation have allowed natural evolution to proceed with minimal human interference. The few studies of the area indicate the existence of many unknown and endemic species, as well as the presence of several species now extinct in other states of the Mexican Republic. In addition, because of its particular geographic situation, this region offers excellent possibilities for biogeographic and evolutionary studies of biological islands.

One of the most interesting zones in Baja California Sur is the Sierra de La Laguna, which is located at the Cape Region between parallels 22°50' N and 24°N; 109°60' W and 110°10' W (Fig. 1). The Sierra de La Laguna is a mountainous complex formed mainly of cretacic granites which reaches altitudes of 2000 meters. This altitudinal gradient presents great climatic variations. In the lower parts, the mean annual temperature is 25° C with a total annual rainfall of 300 mm, while the upper parts have mean annual temperatures lower than 13° C and total annual rainfalls over 700 mm.

Biological Importance

The abiotic factors explained above provide the natural conditions necessary for the development of several kinds of vegetation, principally (1) an arid tropical vegetation from sea level up to 300 meters; (2) a tropical deciduous forest ranging from 300 to 800 meters; (3) an oak forest between 800 to 1200 meters; and (4) an oak-pine forest in the upper parts of the mountains, including the highest altitudes.

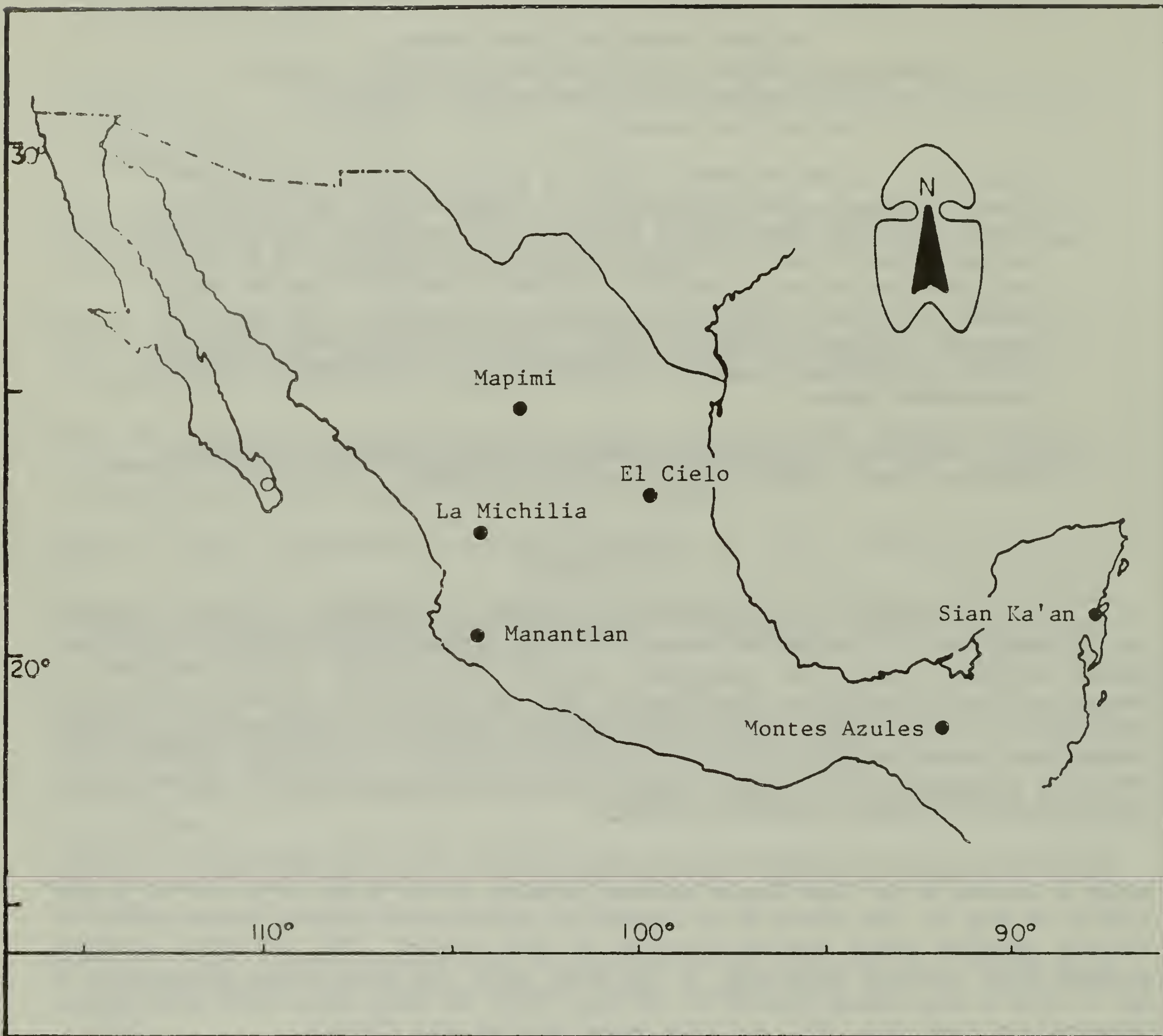

Figure 1. Biosphere Reserves in Mexico (•) and proposed region in Baja California Sur (o) for the establishment of a new reserve.

The Sierra de La Laguna covers a considerable area of the Cape Region, where the pine forest includes 20,000 ha and the tropical deciduous vegetation about 35,000 ha. The occurrence of these types of vegetation is of great importance because they represent the only forests in the entire state of Baja California Sur. The nearest forest on the peninsula occurs 800 km away in the northern part of the peninsula, and it is separated from Mexico's continental forests by 500 km. The Sierra de La Laguna, therefore, may be considered as a great vegetation island surrounded by thousands of square kilometers of desert and sea.

As a result of this geographical isolation, the Cape Region has a high incidence of endemic species and subspecies (Table 1), including most of the endemic species described for the state. However, because of the few studies done in these communities, a great number of plant and animal species remain undescribed.

The Cape Region was isolated from the rest of the continent about ten million years ago during the Miocene (Axelrod 1959). That is why the flora and fauna of the Sierra de La Laguna have developed unique species with insular characteristics. Brandegee (1892) reports that out of 390 genera of plants, 230 are represented by single species; the latter indicates a ratio of genera to species similar to that found in island floras. Other insular characteristics, such as low competitive abilities and great susceptibility to alien predators, occur within several groups of animals in this region; *Coleopterous* species are frequently apterous (Halffter, pers. com.), and several species of lagomorphs and rodents (i.e., squirrels and rabbits) are absent in the pine-oak forest community. These represent only a few examples accounting for the region's biological importance.

Socioeconomic Importance

The Sierra de La Laguna also has considerable socioeconomic importance. This region contains 9 watersheds and gets the greatest amount of rainfall in the state. Vegetation, soil, and substrate allow water storage at the subsoil, which later on is extracted by the inhabitants of the southern parts of the state, particularly from La Paz and Los Cabos. If the forests of the Sierra de La Laguna were destroyed, significant biological and economic consequences could take place.

The prevailing land use at the lower elevations in the Sierra de La Laguna is mostly agricultural, including a relatively low level of livestock activities and orchard cultivations, as well as corn and bean plantings. The inhabitants of the region also exploit several natural products, particularly trees like "mauto" (*Lysiloma divaricata*), "palo zorrillo" (*Cassia emarginata*), and "palo de arco" (*Tecoma stans*), to obtain wood to build their huts or for furniture manufacturing. Tannins are extracted from the "palo blanco" (*Lysiloma condida*) and the "mauto" to tan leathers. Soap substitutes are obtained from the "amole" (*Stecnospherma alimifolium*), and a great number of other plant species are used for medicinal purposes.

In the transition area of the reserve, there are 6 towns with less than 1,000 inhabitants. Also, there are 6 common lands ("ejidos") and 28 settlements between 300 and 500 m above sea level having populations of less than 200 inhabitants each. The local resource management tradition reflects a harmonic equilibrium between the human communities and their natural environment.

Table 1. Occurrence of exclusive or endemic taxa (species and subspecies) of the Cape Region in Baja California Sur.

	Total no. of species reported	Occurs in Pine-Oak Forest only	Occurs in Cape Region only	New species described	Author
Vascular Plants	732	17	72		Brandegee (1892)
	1000	20	150		Leon de la Luz (pers. com.)
Invertebrates:					
Araneae	73	16	73	21	Jimenez (1987)
Collembola	37	1		7	Palacios-Vargas & Vazquez (1987)
Vertebrates:					
Herpetofauna	48		10 sp 5 ssp		Murphy (1983)
Birds	97	3	2 sp 22 ssp		Brewster (1902) Banks (1967)
Mammals	44	4 ssp	2 sp 12 ssp		Galina, Alvarez & Arnaud (1987)

sp = species; ssp = subspecies.

Research Activities

At the Centro de Investigaciones Biological of Baja California Sur (CIB), a research team is working on the basic biological and ecological aspects of the flora and fauna of this region. Floristic and faunistic inventories are being carried out. Studies considering the spatial and temporal distribution of several plant and animal species, as well as different aspects of their population and community ecology, are being developed. Particularly, these studies include floristic and biogeographic analyses of plant communities, descriptions of forest regeneration processes, behavioral studies on several insect species, and the altitudinal distribution, abundance and resource partitioning of the main vertebrate species.

The Terrestrial Biology Division of CIB is looking forward to describing the structure and function of these fragile ecosystems, and also to promoting--in the short term- -their legal protection as part of the Biosphere Reserve System to conserve their valuable resources. We think that the best way to guarantee the maintenance of the natural richness of the Sierra de La Laguna is to offer appropriate alternatives for integrated management of natural resources, in furtherance of the MAB (UNESCO) philosophy.

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THE SIERRA DE MANANTLAN BIOSPHERE RESERVE: THE DIFFICULT TASK OF BECOMING A CATALYST FOR REGIONAL SUSTAINED DEVELOPMENT

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ABSTRACT: The Sierra de Manantlan Biosphere Reserve (SMBR) encompasses approximately 140,000 ha, ranging in altitude from 400 m to 2,960 m in southwestern Jalisco, Mexico. Edaphic and climatic changes along an altitudinal gradient produce a distinct pattern of vegetation zones, starting with tropical dry forest at lower elevations and including oak, pine, fir, and cloud forests near the summits. Rivers and streams originating in the reserve maintain the agricultural economies of several lowland valleys. Lumber is an important forest product and through adequate management can become a constant source of income to the poor rural communities in the area. Local inhabitants use mushrooms, blackberries, orchids, bamboo, freshwater shrimps, fish, wildlife and many other forest products for food, building materials, artesanal crafts and for medicinal purposes. In 1977 a new species of perennial corn, *Zea diploperennis*, which is resistant to major corn viral diseases, was discovered in these mountains, bringing the area to the attention of the international scientific community and general public. Because of its importance in the genetic improvement of commercial corn, *Zea diploperennis* has become the classic example of the need for *in situ* preservation of genetic diversity in wilderness areas. In 1985 the University of Guadalajara created an interdisciplinary institution to conduct research and management activities in the area. The conservation of genetic diversity will be achieved via small-scale sustainable development projects. The project proposes a constant interaction between the government, the university and the communities within the reserve. The initial socioeconomic and ecologial diagnosis is conducted through participatory workshops in which the local inhabitants identify their problems and suggest their solutions through a feedback research process. The implementation of the solutions is a responsibility of the three sectors. In this sense the biosphere reserve serves as a biological conservation entity, as well as a catalytic project for regional sustainable development.

KEY WORDS: Biosphere reserves, ecodevelopment, forestry, ethnobiology, *Zea diploperennis*, Sierra de Manantlan, Las Joyas, Jalisco, Mexico, sustainable development.

Mexico covers approximately two million square kilometers and constitutes one of the most ecologically complex regions in the world due to its latitudinal location, its geological history as a "land bridge" between two continents, and its topographic complexity. Practically all biomes of the world are represented within its boundaries (Rzedowski 1978). It is rich in species of plants (over 25,000 species of flowering plants estimated [Gomez-Pompa 1985]) and animals (over 3,000 species of vertebrates [LNLJ 1987]), and it completely encompasses the zone of abrupt transition between the Nearctic and Neotropical biogeographical regions (Rzedowski 1978).

Mexico suffers from environmental deterioration observed in so-called underdeveloped countries (e.g., deforestation, desertification, soil erosion, floods and extincton of species). However, Mexico also has the most populated city in Latin America and suffers the problems of the so-called developed or overdeveloped countries (e.g., air and water pollution, oil spills, and recently, potential nuclear pollution). The reasons for these environmental problems are complex, but they include rapid demographic growth; implementation of economic and sociopolitical models (international as well as national) that encourage natural resource destruction and generate social inequalities and poverty; the lack of trained professionals; and the lack of access to and production of technical information and adequate technology that permit ecologically sustainable development alternatives (Jardel 1985).

With these problems, decision makers in Mexico are reluctant to accept "don't touch" conservation schemes. The failure of many national parks is an example. Conservation and development must be designed as compatible and necessary activities. It is in this context that the biosphere reserve concept is becoming the most important model to achieve conservation, preservation and sustained use of ecosystems.

The Sierra de Manantlan Biosphere Reserve (SMBR) was established by the Mexican government in March 1987 following the guidelines of the World Conservation Strategy and UNESCO's MAB Program. It follows the "Mexican modality" of biosphere reserves (Halffter 1981) and is part of the Mexican National System of Protected Natural Areas.

History of the Project

In 1977, one of us (Rafael Guzman-Mejia) began a systematic search for an "extinct" species of grass, *Zea perennis* (Guzman 1984). This search was part of the "Flora de Jalisco" project of the Instituto de Botanica (Universidad de Guadalajara), and was spurred by a Christmas card sent to Mexico by Dr. Hugh H. Iltis (University of Wisconsin) that depicted the extinct species. This search led to the rediscovery of *Zea perennis* and the discovery of *Zea diploperennis* (Iltis et al. 1979)[1]. This ordinary-looking grass has become the classic example of the need for *in situ* preservation of genetic diversity in wilderness areas. It has been an important link in the development of theories on the evolution of corn (*Zea mays*). Being diploid, *Zea diploperennis* is the only wild corn that is resistant or immune to seven of the most important corn viral diseases and can hybridize with commercial corn (Iltis et al. 1979; Nault 1981). It is adapted to high altitude wet conditions; and it is perennial, growing from rhizomes as well as from seeds.

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[1] In addition to the development of the biosphere reserve, the history of the discovery and the events following serve as a case study related to the sociology of a scientific discovery involving such aspects as: the role of support for basic research, student-teacher interactions, international academic cooperation, national rights over genetic resources, the involvement of multinational corporations, and the role of international conservation organizations. These dimensions are beyond the scope of this paper.

The thought of breeding a perennial disease-resistant corn that would not need to be planted each year and could save millions of dollars in fuel consumption, labor, soil erosion, and losses to viral diseases captured the imagination of many people when the news of its discovery was published in 1982, as a front-page article in *The New York Times.*

A survey of the populations of *Zea diploperennis* in the Sierra de Manantlan revealed that the whole mountain range was of extreme biological and economic importance in a regional, national and international context. The conservation project expanded from one with a one-species approach to one with an ecosystem approach. As the biosphere reserve idea matured, it became obvious that an interdisciplinary conservation strategy was needed to address all the complex problems of the region.

During the initial stages of the project, the Laboratorio Natural Las Joyas (LNLJ) of the Universidad de Guadalajara compared various management categories following Miller's (1980) methodology. Traditional categories (forest reserve, national park, wildlife refuge, ecological reserve) were not adequate to achieve the conservation and development objectives for the area and, by a process of elimination, the biosphere reserve category was determined to be the most viable alternative. The State Government of Jalisco promoted the project and obtained support and approval from the Secretaria de Desarrollo Urbano y Ecologia (SEDUE)and the President of Mexico, Lic. Miguel de la Madrid Hurtado.

Characteristics of the Sierra de Manantlan Biosphere Reserve

The SMBR mountain range is found in the Sierra Madre del Sur. It is located in southwestern Jalisco at approximately 19° N latitude, 55 km from the Pacific Ocean. It covers 140,000 ha and ranges in altitude from 400 to 2,960 m above sea level (Guzman 1985; LNLJ 1987). The western portion of the mountain range is of igneous origin (Guzman and Lopez 1987) and the eastern portion is composed of calcareous rock, with a karst topography. This area harbors a complicated system of caves, including an underground stream over 3 km long (LNLJ 1987).

The reserve has a wide diversity of vegetation types. Tropical deciduous and subdeciduous forests and dry scrub are found in the lowlands. Mid-altitudes are dominated by oak forests. The higher altitudes are dominated by pine and fir forests. In the wet ravines and moist hillsides, the cloud forest dominates with trees of the genera *Magnolia, Clusia, Fraxinus, Quercus, Cornus, Tilia,* and *Carpinus*: with *Alnus, Conostegia, Ficus* and *Inga* along streams. More than 1,500 species of plants have been reported for the reserve. Over 1,500 species of flowering plants are endemic to the region (only 20% of the vegetation survey of the reserve has been completed [LNLJ 1987]).

The reserve is also rich in animals; 295 species of birds (over 30% of the species in Mexico), 76 species of mammals (16% of the species in Mexico), 45 species of reptiles, 20 species of amphibians and 16 species of fishes have been reported (LNLJ 1987). The area is important for migratory birds; approximately 30% of the species exhibit complete or partial altitudinal or latitudinal migrations.

The vegetation and fauna of the area reflect the region's location within the Nearctic-Neotropical transtion zone. Many species find their continental geographical limit of distribution in the region (LNLJ 1987). The endemism found at higher altitudes reflects long periods of isolation in forests that are considered to be relicts of the Pleistocene vegetation (Rzedowski 1978).

The human population in the SMBR is approximately 5,000, but a much larger number of people live adjacent to the reserve and are partially dependent on its resources. The reserve encompasses private lands (20%), indian communal lands (20%) and ejido lands (60%). Since no land has been expropriated or bought, this biosphere reserve functions as a huge zoning experiment. The residents of the communities of Cuzalapa and Ayotitlan in the southern slopes are descendants of Nahuatl-speaking people whose ancestry has been traced to the time of the Spanish conquest. Archeological evidence suggests that cultural continuity exists in some villages well into the prehistoric period. A very small segment of the population continues to speak the indigenous Nahuatl language (the language of the Aztecs) and they are likely the descendants of the very first human inhabitants of the SMBR (Kelly 1945, 1949; Bruce Benz, unpub. ms.).

Although the agricultural and cultural systems in these communities have not been studied, they include the use of indigenous strains of maize, beans and squash, as well as traditional agroecological practices. Traditional uses of forest resources include the use of firewood and the seasonal hunting and gathering of mushrooms, blackberries, orchids, bamboo, tubers, wildlife, fish, freshwater shrimps, and many other forest resources for food, building materials, artesanal crafts and for medicinal purposes.

The most important resource is water. It is employed in domestic use and small-scale agriculture. However, water produced in the reserve also sustains the agricultural economies of some large valleys like Autlan, El Grullo, Casimiro Castillo, Purificacion and others that produce crops for export. Water from the reserve is also used for mining and sugar production activities.

Conservation and Social Problems

Most inhabitants depend on small-scale agriculture, although external wage labor and the selling of lumber and grazing rights provide additional sources of income. The people of the reserve suffer high rates of illiteracy, malnutrition and ill health (LNLJ 1987). The major conservation problems in the reserve are slash and burn agriculture, forest fires, overgrazing, logging activities, poaching and unsustainable levels of firewood consumption. Slash and burn agriculture is the traditional form of cultivation. At the present time it is conducted in an unsustainable manner, converting forested areas into fields and pastures and causing soil erosion on the steep slopes. The fires are often uncontrolled and, although unintentional, are the main source of forest destruction. Abandoned cleared areas are used for cattle grazing. Overgrazing and recurrent fires prevent forest regeneration. Cattle also roam freely in the forest and concentrate in cloud and gallery forests during the dry season, causing streambank erosion, soil compaction and impeding forest regeneration.

Firewood represents approximately 80% of the source of energy for the rural communities (LNLJ 1987). The scarcity of firewood is becoming an important problem, especially in the area surrounding the villages. Logging activities began in the eastern portion of the reserve at the turn of the century. However, in the western portion it began in the 1940s. The lumber activities were sporadic and did not benefit the local inhabitants. In the last 35 years, 17 lumber mills have operated in the reserve. Each created company towns of hundreds and sometimes over 1,000 people. However, most of the people were laborers brought in from other areas. When the mills moved to other sites after depleting the harvestable trees, the town disappeared. The town sites can be identified by the huge mounds of sawdust remaining in the area. Logging has created internal problems in the villeges because it has been a source of corruption and community strife, and some view it as a theft of their forest resources.

Aside from the social problems created by the logging companies, the harvesting operations have not been conducted correctly. An excess number of roads have been constructed that have scarred portions of the landscape and created erosion, siltation and soil compaction problems. Because only the largest portions of tree boles are used, the resource is underutilized, and the wood that has been left on the ground increases fire risks. High quality species like those of the genera *Abies, Magnolia, Juglans* and *Cedrela* have become very scarce. Overall, forestry activities have had a negative impact on the natural resources of the reserve and on its people; however, if the communities can control the wood production and extraction process and if this activity is conducted in a sustained manner, it can become an adequate development alternative.

The conservation of genetic resources in the SMBR will only be achieved through the transformation of the present unjust and destructive production practices and through the development of sustainable and diversified resource utilization alternatives. This type of development-through-conservation approach must benefit in the short and long run the inhabitants of the reserve and adjacent areas. Success depends on the active participation of the people. The reserve is seen as a biological conservation entity, as well as a catalytic project of regional sustainable development.

The Laboratorio Natural Las Joyas

The LNLJ was created by the University of Guadalajara in March 1985 with the following objectives: (1) to promote the creation and development of the SMBR; (2) to conduct scientific research and monitoring activities on the structure and function of ecosystems in the SMBR; (3) to contribute to the training of technicians and scientists in the fields of ecology and management of natural resources; (4) to develop and apply techniques for the sustained use of natural resources; and (5) to participate in the management and development of the SMBR. To achieve these, it manages a 1,245-ha research station, the Las Joyas Scientific Station in the Sierra de Manantlan at 1,900 m in altitude. Its headquarters are located in the town of El Grullo within the area of influence of the reserve, and it keeps a liaison office in the city of Guadalajara.

The LNLJ is an interdisciplinary institution that is composed of various programs: (1) Ethnoecology; (2) Environmental Education; (3) Ecodevelopment; (4) Forestry; (5) Soils and Watersheds; (6) Flora; (7) *Zea diploperennis*; (8) Fauna; (9) Cartography and Photointerpretation; (10) Information and Data Processing; (11) Publicity; (12) Public Relations; (13) Field Station Management; and (14) Administration.

The Ethnoecology Program studies the local culture, folklore, history, social structure, social problems, and land tenure of some of the rural communities in the reserve. It also studies the traditional use of forest resources. A community health clinic has been initiated. The initial socioeconomic diagnosis is being conducted using the participatory workshop technique. During these workshops, the information generated immediately becomes part of the general knowledge of the community. Problems are identified in the meetings and possible solutions suggested. In this way no solutions or programs are imposed from outside the community. Organization of the community is an important aspect, because an ecodevelopment project that is a technical success can be a social failure if the community cannot implement it or does not benefit from it.

The objective of the Environmental Education Program is to teach the basic ecological processes that maintain the life-support systems of the communities. Through this program we have been obtaining support for the biosphere reserve project. By knowing the ecological and economical importance of their natural resources, the people of the reserve begin to protect and defend them; this is the first step permitting them to effectively control and benefit from their resources.

In conjunction with the Ethnoecology Program, this coordination has been conducting workshops with children in the villages, utilizing different techniuques (e.g., puzzles, songs, puppet shows, games and improvised theater plays). Three-week intensive ecology summer camps are being conducted for Guadalajara city children and the reserve's rural children. The parents of the children have become strong supporters of the program. An environmental education pilot project has been initiated with over 20 elementary school teachers of the region. Sixteen radio programs have been produced explaining the conservation objectives of the reserve. The programs are being aired through sixteen radio stations covering the reserve and its area of influence.

The Ecodevelopment Program attempts to raise the standard of living of the people, including health and education, through the implementation of environmentally sound development projects. Due to lack of trained personnel, this has been the slowest program to get under way. The projects that are being initiated include: a fruit-tree grove; aquaculture and mushroom production projects; and advising on corn and vegetable production, firewood use and production, and honey production. With the cooperation of the Forestry Program, a reforestation project of two town plazas in the SMBR was initiated.

The Forestry Program has initiated a nursery project at Las Joyas Scientific Station, where germination trials with local species of trees have begun. Research on forest stand dynamics, succession and regeneration in burned and logged areas, and control of logging residues have been initiated. The forest inventory conducted at Las Joyas includes various parameters for characterizing wildlife habitat.

The Soils and Watershed Program has been conducting soil composition, geology and comparative soil erosion studies at Las Joyas. Results are mapped at a 1:10,000 scale. This work will be expanded to the entire reserve at a less detailed scale. In the future, hydrological and watershed dynamics studies will be included.

The Flora Program is conducting a five-year inventory of the plants of the SMBR. It identifies the species present and their distribution, abundance, general phenological patterns, and potential uses. A herbarium has also been established. Studies nearing completion include: (1) a review on the algae; (2) medicinal plants used in the Sierra de

Manantlan; (3) the ferns of the Sierra de Manantlan; (4) a comparison of three methods of forest sampling; and (5) a guide to the trees of the Sierra de Manantlan. A rustic orchid house is being established at Las Joyas to conserve and use some of the native species. A study monitoring the phenology of 26 species of trees in the cloud forest is in its second year. For *Magnolia* spp., detailed information is being obtained on site characteristics and production of leaves, flowers, fruits and seeds.

The *Zea diploperennis* Program is conducting studies on the autecology of the species. A comparative study of root damage to *Zea mays* and *Zea diploperennis* by insects has been completed. This study constitutes the first quantitative description of the seasonal patterns of abundance of a rhizofagous insect community in high altitude cloud-forest habitats. An experimental area has been established to compare the growth, survival and seed production patterns of seed-produced plants of *Zea diploperennis* and rhizome-produced plants. A phytosociological study of the sites where *Zea diploperennis* grows is being completed.

The Fauna Program is conducting an inventory of the species of the reserve. Initial survey work will provide information on (1) species diversity; (2) habitat distribution patterns; (3) altitudinal distribution; (4) seasonal abundance patterns; (5) endemism; and (6) biogeographical affinities. The second stage involves population studies of important species or groups of species. These include density, diet, reproduction and habitat requirement studies. Three studies of insects and three of vertebrates (fish, birds, and bats) will have been completed by the end of 1988.

The Cartography and Photointerpretation Program has produced more than 35 maps covering such topics as: geomorphology, soils, watersheds, drainage systems, vegetation types, topography, critical areas, communication routes, land tenure, and many more. A study describing changes in land use patterns utilizing time-series aerial photographs is planned.

The Information and Data Processing program is establishing a data bank for the SMBR that will permit quick retrieval and integration of information. It gives advice to researchers on data storage, use and statistics. A survey has been completed on the availability of technical information on conservation, biology, ecology and natural resource management in the libraries of the region. The library of the LNLJ has been initiated.

The Publicity and Public Relations Programs design posters, programs, and agendas to promote the activities of the LNLJ and the SMBR. The drafters give support to the technical work by drawing scientific graphs and figures, as well as explanatory drawings for the environmental education work in the rural communities. They are now in the process of designing a biosphere reserve brochure. Public relations work involves contacts with newspaper reporters and the general public, as well as orgainizing symposiums, shows and interagency meetings. Our effective publicity and public relations work was one of the factors that permitted the speedy declaration of the reserve. Over- all, in the past one and a half years, members of the Laboratorio Natural Las Joyas have given over 100 conferences and presentations to professional groups, civic groups, children, government officials, radio and television audiences.

The Field Station Management administers and coordinates public use activities at the Las Joyas Scientific Station. It also performs protection and collaborates on field research.

Most research activities in this initial stage have been conducted at the Las Joyas Scientific Station. The station has one rustic cabin with dormitory space for twelve scientists. Four guards live in the station and conduct protection activities. The station manager and field assistants live permanently in three other cabins. More extensive infrastructure is planned for the near future. The station, as well as the community-based work, have been the link to the people of the reserve. The procedures and methodologies developed at the station will be models to implement in the rest of the reserve.

The Administration is responsible for financial control activities, administrative systems, personnel management, maintenance and support activities, and in obtaining financial support.

The Planning and Administration Process

Administration and management of the SMBR are now being initiated in a formal way. Because of the ecological, topographic, social, legal and political complexities of this project, the SMBR must be administered by an entity that encompasses federal, state and municipal government levels, the communities of the reserve, and the local promoter institution, the University of Guadalajara. However, it is necessary to establish a conceptual and theoretical framework for reserve management to ensure that the original goals and objectives are not lost in the complex interagency administrative process. Each agency and institution has its own goals and objectives, and these must be coherently unified towards the common goals of the reserve.

For the management of biosphere reserves, the need "to set up some simple coordinating group where those in charge of core areas, of the buffer zone and of experimental research areas would meet with representatives of the local people and of the administrative authorities of the transition area" has been recognized (Batisse 1986). This is an extremely complex and difficult endeavor. It is hindered by interagency "territoriality;" conflicting goals; pressure from political, civil or economic groups; and lack of understanding of the objectives of a biosphere reserve. This issue requires much more in-depth analysis, as the success of a reserve might depend more on this than on technical solution to environmental problems.

In many cases, the reserve's planning process is not more than a mere administrative formality or theoretical exercise. To be functional, the elaboration of the management plan must be closely linked to its immediate management and research activities. In this planning process it is essential that the communities participate fully. Management and conservation priorities and alternatives imposed from outside the communities and based on ethnocentric values alien to these, will not succeed unless the priorities and values recognized by the indigenous people themselves are taken into account, especially if they will eventually become the managers of the reserve's resource (Halffter 1984).

A project of this magnitude is costly, and in a country with urgent development needs, a high foreign debt and chronic poverty, it might seem to be a luxury. Who pays for these conservation costs? To answer this question, we first ask, "Who benefits from this project?" Obviously the people of the reserve benefit; they pay in the form of time, labor and risks taken in the development project and support activities. The sponsor institution, the University of Guadalajara, benefits in establishing a research, educational and resource management program, and pays for supporting the program. The national government benefits at its three levels (municipal, state and federal) because the project insures the sustained use of resources, encourages local development, increases the standard of living in the region, and produces trained professionals. The government pays most of the operational costs of the reserve.

The international community benefits in many ways. Migratory birds do not respect international boundaries, and their conservation is the responsibility of all the countries involved. Genetic resources could also benefit the world at large. For example, the viral diseases to which *Zea diploperennis* is resistant produce greater crop damage at the present time to corn producers in the United States than in Mexico.

Research on transferring disease-resistant traits to commercial corn is being conducted by multinational corporations and foreign universities, not by Mexican institutions. This means that, in the short run, the beneficiaries of the discovery of this genetic resource and the genetic engineering and hybridizing breakthroughs will be the corn producers of developed countries, not of Mexico. These situations are illustrative of the international responsibility in financing the conservation of wilderness areas in Latin American countries.

Our interdisciplinary approach to the management of a biosphere reserve, the zoning procedure and the work approach with the communities is one that should provide useful lessons for other areas. The key to conservation in core areas is good management of the buffer and transition zones. This implies the involvement of many government agencies, rural communities and interest groups. It is a difficult task to establish an interinstitutional coordinating mechanism that internalizes the objectives of a bioshere reserve and gives full representation to the inhabitants of the reserve. However, this is a generalized problem in many Latin American reserve projects that must be resolved if an integrated and flexible system of biosphere reserves is going to succeed.

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The Sierra de Manantlan Biosphere Reserve and the Laboratorio Natural Las Joyas exist thanks to the support of literally hundreds of people. However, we would like to mention a few whose support has been crucial during different stages of the project:

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The information presented here summarizes the work of the members of the Laboratorio Natural Las Joyas and represents the result of many hours of discussions, field work, laboratory work, library work, feelings of joy and frustration, and the sacrifice of personal goals toward the goal of creating the Sierra de Manantlan Biosphere Reserve. We give our most important acknowledgement to the personnel of the Laboratorio Natural Las Joyas. Our work is dedicated to those which the project intends to benefit: the people of the Sierra de Manantlan and their biotic resources.

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SIAN KA'AN: A NEW BIOSPHERE RESERVE MODEL IN MEXICO

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ABSTRACT. The biosphere reserve of Sian Ka'an is considered as the only viable alternative for the conservation of natural resources in Quintana Roo, since the exploitation of wildlife and vegetation is both essential and forms part of the cultural background of the native inhabitants. Sian Ka'an comprises terrestrial, marine and freshwater ecosystems which are representative of the Mesoamerican and West Indian regions. The reserve is located in the east central part of the Yucatan Peninsula and represents more than 10% of the territory of Quintana Roo. Its most outstanding characteristic is its management form, known as the "Modalidad Mexicana" (the "Mexican Modality"), in which those people considered inhabitants of the reserve and the surrounding areas should act as the main protectors and managers of the resources, and are also the first to receive any benefits accruing. Federal, state, and municipal governments, research institutions, non-governmental organizations (NGOs), and local inhabitants are all involved in the administration of the reserve.

KEY WORDS: Biosphere reserve, Sian Ka'an, Quintana Roo, CIQRO, Mexico, indigenous peoples, traditional land use.

The area of the Biosphere Reserve of Sian Ka'an (Fig. 1) is one of the last remaining places in the country that contains ecosystems representative of the subtropical zone. These ecosystems are characterized by their great genetic diversity and large number of endemic species.

The isolation of Quintana Roo allowed it to conserve the greater part of its natural resources intact until the first years of the decade of the Seventies. Until then, only two economic activities had been realized in the tropical forest: the milpa (shifting cultivation) of the Mayans, and forestry. The latter has focused on woods classified as precious, but other tropical woods, in which the potential value is equally high, have been squandered and burned. To date, it is estimated that only 35% of the forest in Quintana Roo remains undisturbed (Careaga-Viliesid 1983).

Worried by this situation, the state government entrusted the Centro de Investigaciones de Quintana Roo, A.C. (CIQRO) with the task of formulating mechanisms to avoid

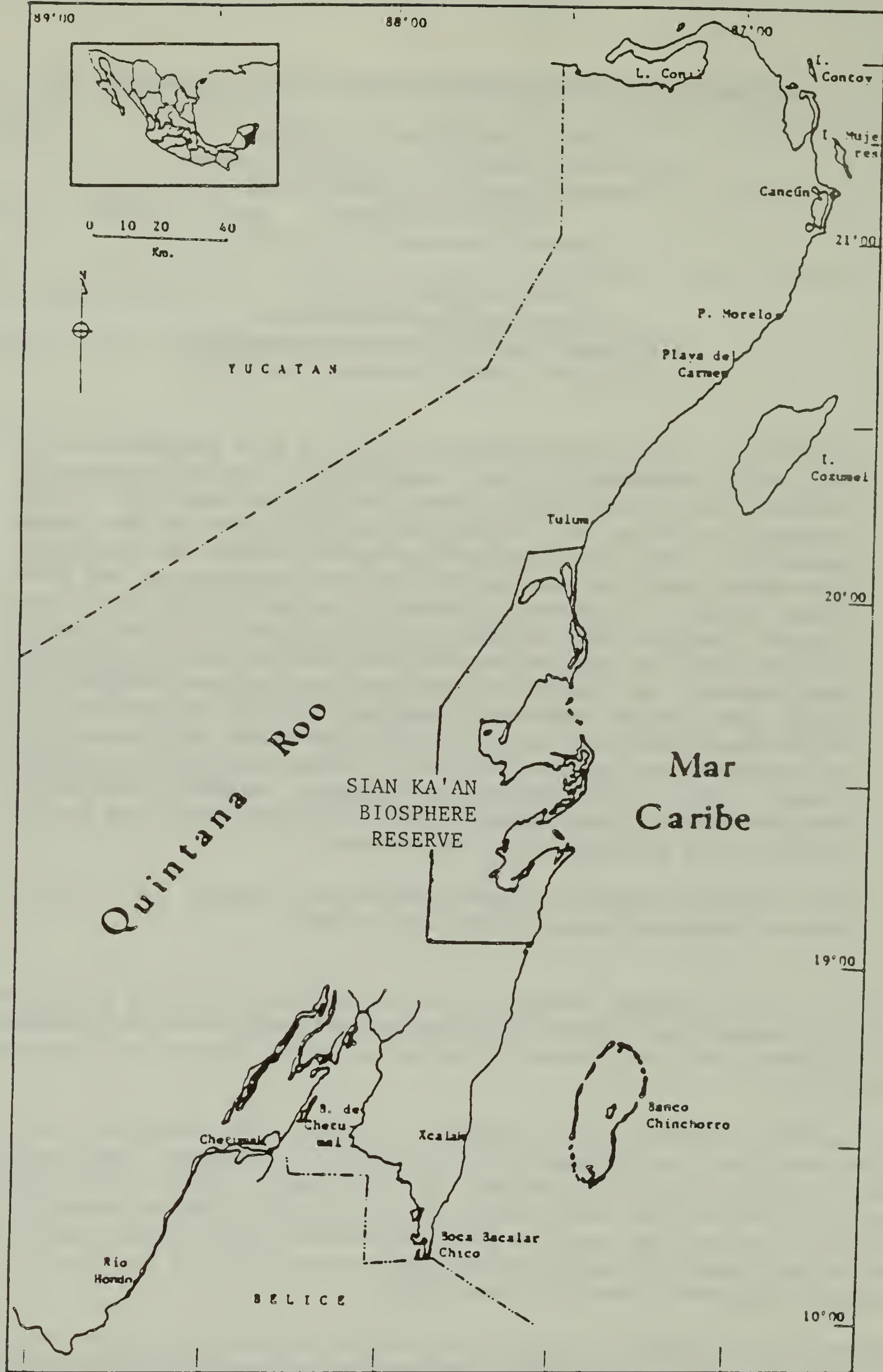

Figure 1. Geographic Location of the Biosphere Reserve of Sian Ka'an.

future losses of forests and natural resources in Quintana Roo. Thus the first plans for the establishment of a biosphere reserve were born in 1979, with the creation of CIQRO (Careaga-Viliesid 1983).

The Biosphere Reserve of Sian Ka'an was decreed by the President of the Mexican Republic in January, 1986. It is located in the east central region of the Yucatan Peninsula and comprises an area of 528,000 hectares; of these, 150,000 consist of bays, salt marshes, and swamps (Lopez-Ornat 1983).

The reserve belongs to the biogeographical province "Campechana" and is influenced by the "Mesoamerican" and "West Indian" regions. It is a calcareous plain, partially uplifted in recent epochs (Quaternary) within the last two million years (Buterlin 1958). It has a mean annual precipitation of 1200 mm, with maximum rainfall occurring in May to October, and a mean annual temperature of 25.4^{o} C. The climate shows oceanic influence due to the reserve's proximity to the sea and has been classified as Hot Subhumid with summer rains (Lopez-Ornat 1983).

In general, the soils of Sian Ka'an are poor, young, little developed, and very stony. The subsoil is derived from white sandy limestones called "Saskab." The "Tzekeles" are shallow, black soils formed by the collection of vegetable matter in cracks in the rocks. The "Ak'alches" are deep, fine textured soils prone to flooding, formed by the washout of colloids from higher zones (CIQRO 1980).

Sian Ka'an contains representative samples of the principal ecosystems found in the Yucatan Peninsula and the Caribbean. Both the flora and the fauna exhibit elements of the Mesoamerican and West Indian provinces. The principal environments are:

(a) Tropical forests: Tropical evergreen forest (with trees of medium height); tropical deciduous forest; and low level forests prone to flooding.

(b) Vegetation subject to flooding: Keys; fringe mangrove; low mangrove; salt marsh and grassland; palm groves; and flood-prone tree communities.

(c) Shrub communities: Secondary vegetation; burned brush areas; and coastal dune vegetation.

(d) Water bodies: Natural sink holes (cenotes); interior lagoons; coastal lagoons; and runoff channels.

(e) Reef platform: Marine environment, found within the reserve up to the 50-meter isobath behind the reef chain.

Flora and Vegetation

The flora of Sian Ka'an is extremely varied due to the presence of a large number of different environments. It is estimated that the number of species could exceed 1200. All these species are grouped in different communities, depending on edaphic and soil conditions and on the influence of mineral salts. The types of vegetation exist in a complicated mosaic, the following being the principal types (Olmsted et al. 1983):

• Evergreen forest (medium and low): More than 50% of its elements conserve their foliage during the dry season; the height of the canopy varies between 12 and 25 meters. The dominant species are the following: black chechen (*Metopium brownei*); sapotillo (*Manilkara zapota*); chacah (*Bursera simarluba*); chit palm (*Thrinax radiata*); and nacax (*Coccothrinax readii*).

• Deciduous forest (medium and low): Between 50% and 75% of the dominant species lose their leaves in the dry months; they possess floristic elements which coincide with the Evergreen forest; however, there are two tree species which characterize this type of forest: the "despeinada" (*Beaucarnea ameliae*) and the kukab palm (*Pseudophoenix sargentii*).

• Low forest prone to flooding: Found in small craters and dispersed ak'alches. The dominant species are black chechen, sapotillo, logwood (*Haemotoxylon campechianum*), and the bullet tree (*Bucida spinosa*) (Belizian name).

• Palm groves: The tasiste palm (*Acoelorrhaphe wrightii*) is a palm of 4–8 m in height found in areas of flooding or transition.

• Marsh and Grasslands: These occupy large areas in Sian Ka'an and the dominant species is sawgrass (*Cladium jamaicense*). Periodically they suffer damage from natural fires, but they recover through their rhizomes.

• Fringe Mangroves: Found in the keys and the borders of coastal lagoons, with heights up to 15 m. The typical components are the red mangrove (*Rhizophora mangle*), the black mangrove (*Avicenia germinans*), and the white mangrove (*Laguncularia racemosa*) in this order of resistance to water salinity.

• Low Mangroves: Large areas of *Rhizophora* of no more than 2 m in height.

• Hammocks: These are "islands" of forest between marshes. They grow on patches of soil somewhat more elevated and therefore are safe from flooding, salinity and probably from fires. Their sizes vary from a few dozen meters in diameter to more than 1 km; the largest usually have a cenote (sink hole) in the center.

• Dune vegetation: There are approximately 100 km of coastal dunes in a narrow fringe of 100–200 m width; 90% consists of cultivated coconut palms (*Cocus nucifera*) and 10% of typical Caribbean elements such as the chit (*Thrinax radiata*) and the wild grape (*Coccoloba cozumelensis*) (Belizian name).

Fauna

Within this varied vegetation mosaic exist appropriate habitats for an equally important number of faunal species. Among the principal mammals, the five neotropical species of felines stand out: the jaguar (*Felis onca*), the puma (*F. concolor*), the ocelot (*F. pardalis*), the margay (*F. weidii*); and the jaguarundi (*F. yaguaroundii*). Other species present are the tapir (*Tapirella bairdii*), the manatee (*Trichechus manatus*), the spider monkey (*Ateles geofroyii*), the howler monkey (*Alowatha punctata*); the white-tailed deer (*Odocoileus virginianus*), the red brocket (*Mazama americana*), and the spotted cavy (*Agouti paca*) (agouti) (Garcia-Salazar 1983).

It is estimated that there are more than 300 bird species, many of them migratory. Among these, no less than 70 are aquatic, with significant species being: the frigate bird (*Fregata magnificens*), brown pelican (*Pelecanus occidentalis*), the cormorant (*Phalacrocorax olivaceus*), the wood stork (*Mycteria americana*), the white ibis (*Eudocimus albus*), the roseate spoonbill (*Ajaia ajaja*), and 15 species of herons. Among the birds subject to hunting are the ocellated turkey (*Agriocharis ocellata*), the great curassow (*Crax rubra*), and the crested guan (*Penelope purpurascens*) (Garcia- Salazar 1983).

Reptiles include the swamp crocodile (*Crocodrilus moreletti*), the mangrove crocodile (*C. acutus*), and the loggerhead (*Caretta caretta*), green (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) (Garcia-Salazar 1983).

Within the marine zone, it is important to note the presence of two large coastal lagoons, which are considered as breeding and refuge zones for several species of both ecological and economic importance. Some areas show estuarine characteristics, receiving subterranean contributions from the freatic layer (Herrmann-Martinez et al., in prep.).

The physical-chemical characteristics of these bays are distinctive in comparison with other Mexican coastal lagoons. The concentrations of nitrates, nitrites, phosphates and silicates are similar to those found in some coastal lagoons in Baja California, considered extremely productive (Herrmann-Martinez et al. 1986).

A measure of their productivity can be noted in the concentrations of chlorophyll A and C, which show maximums of 2 and 9 mg of chlorophyll per cubic meter respectively, and phytoplankton concentrations greater than 150,000 cells per litre (Herrmann-Martinez et al., in prep). These unexpected primary biological conditions give rise to great biotic wealth, principally associated with the marine grass communities and the mangrove and coral areas.

One of the most important lobster fisheries in Quintana Roo is located within the reserve. Here, more than 150 fishermen (approximately 70% of the economically active population of Sian Ka'an), grouped in two cooperatives, are dedicated to this activity. It is a type of artesanal (craft) fishing, based on the use of artificial habitats made of wood and cement, called "casitas cubanas" or shadows (Miller 1986; Cesar-Dachary and Arnaz-Burne 1986). The active participation of the cooperatives in the management of the reserve has been one of the principal factors in the initial successes of Sian Ka'an.

Cultural Heritage

While there is ample evidence of the abundance and diversity of germplasm and of the excellent state of conservation in the Biosphere Reserve of Sian Ka'an, we believe that several additional characteristics make Sian Ka'an unique. For instance, the cultural heritage of the Mayan civilization is still present in the reserve, both in the abundant and important archaeological sites that have been found therein, and also in the legacy of traditional Mayan farming techniques and ethnobotany; the application of this knowledge, characterized by deep respect and understanding of the environment and its resources, is presently still under way through local farmers and ethnobotanists of Mayan descent (Carrillo-Barrios-Gomez, 1986).

Table 1. Comparison of the main guidelines for biosphere reserve administration between the Mexican Modality and Sian Ka'an.

Principal Guidelines	Mexican Modality (Halffter 1984)	Sian Ka'an
Independent administration of the biosphere reserve through research institutions	X	
Incorporation of local populations and institutions in the common task of germplasm conservation	X	X
Incorporation of regional socio-economical problems into research and development work at the reserve	X	X
Consideration of the reserve as part of a global conservation strategy	X	X
Incorporation of designated representatives of all government levels to act as the highest authority. Administration through a designated Director		X
Incorporation of NGOs and other organized community groups in the common task of germplasm conservation		X
Designation of an Academic Institution to act as Technical Coordinator, and one Council of Representatives to represent the needs of the local populations		X

Furthermore, the low human population density within the reserve (less than 1000 inhabitants) and the presently low demographic pressure, together with the decisive and active political and economic support from all levels of government (federal, state and municipal/county), give Sian Ka'an a high degrce of stability, which bodes well for the long-term success of any biosphere reserve.

Organization and Administration

The existing diversity of biosphere reserve models between and even within countries, has been recognized and accepted as a characteristic of the international network of biosphere reserves since 1976; hence, there isn't a unique and accepted model (Halffter 1984). As long as the basic characteristics, functions and objectives of biosphere reserves are included (UNESCO 1984), an operational framework can be developed to satisfy the specific characteristics of a biosphere reserve.

In Sian Ka'an, it has been recognized that an outstanding feature of this reserve is its mode of administration. It is characterized by the active and formal participation of all levels of government, the local population, the academic community, non-governmental organizations and other organized community groups. This structure is a modified version of the "Mexican Modality" for biosphere reserves developed by Halffter (1984). Table 1 summarizes and compares both models.

Figure 2 shows the basic organization for Sian Ka'an. It is the result of five years of experience in this reserve and represents a new model for biosphere reserves in Mexico. Its most important components are described below.

The Intersecretarial Commission is presided over by the Secretary of Urban Development and Ecology (SEDUE) and includes the heads of the federal agencies involved with the reserve (e.g., Fisheries, Agriculture, Education, etc.). Its main objective is to establish an integral policy for Sian Ka'an. The Commission is mainly symbolic in nature, but it represents the commitment of the federal government to conservation in this biosphere reserve.

The Board of Directors is presided over by a representative from SEDUE and includes a representative from the state government of Quintana Roo (currently, the Secretary of Education and Culture), and by a representative from each of the two municipios (counties) where the reserve is located (currently, the mayor of the "Municipio Cozumel" and the mayor of the "Municipio Felipe Carrillo Puerto"). The structure of this board is being modified to include the governor of the state as the presiding authority.

The Board of Directors, representing the highest operational authority in the Biosphere Reserve of Sian Ka'an, integrates the three levels of government recognized in Mexico. In this context, it is a unique political and administrative body, created to operate the reserve and coordinate the actions therein. There is currently no precedent or similarity with other biosphere reserves in this country. Only time will allow us to assess its benefits or shortcomings.

The most important functions of this Board include the approval of guidelines, policies and regulations; periodic evaluation of activities; the authorization of foreign activities; and the appointment of the Reserve's Director.

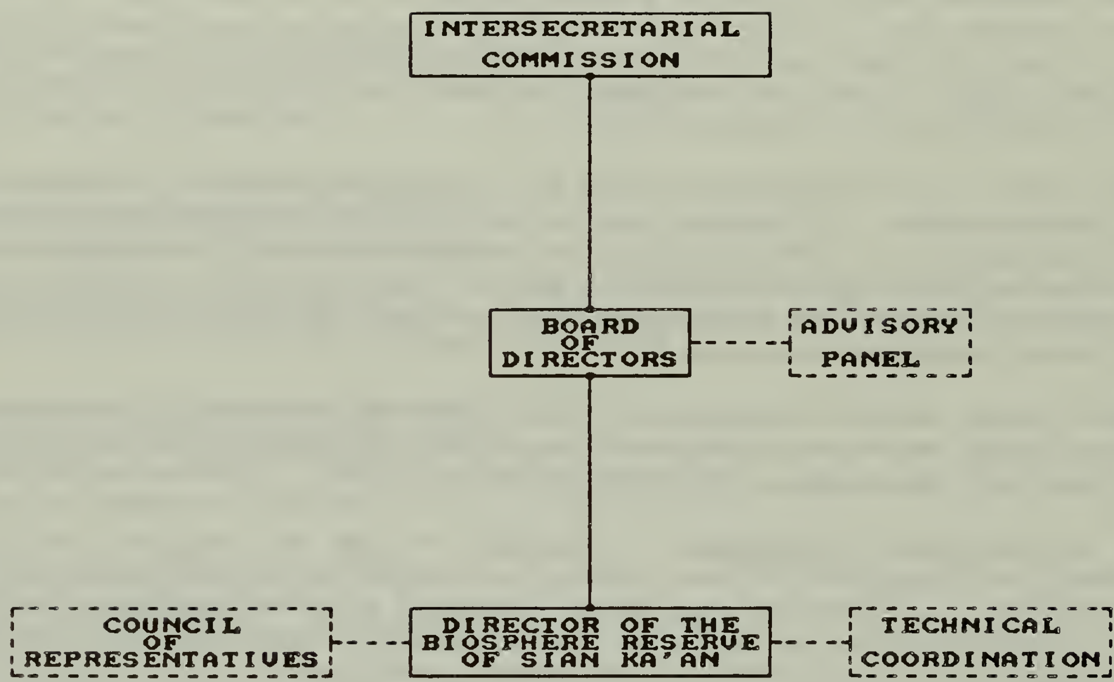

Figure 2. Basic organization for the Biosphere Reserve of Sian Ka'an.

The Director of the Reserve is the principal administrator with authority to implement all existing regulations and carry out all neccesary legal and administrative measures to implement conservation policies in the reserve. The Director also is responsible for the implementation of all resolutions approved by the Board of Directors; the development of basic administrative functions; and the implementation of pertinent actions derived from close and constant consultation with the Council of Representatives and the Technical Coordinator of the Reserve (i.e., actions related to the local population, research, monitoring, education, and management).

The Council of Representatives is presided over by a representative chosen by the inhabitants of the biosphere reserve. Only local inhabitants may be appointed to this council. It is includes one representative from each of the main local populations in the reserve (i.e., fishery cooperatives, farmers, hotel owners, etc.).

The Council represents the needs of the local populations in the reserve. In this context, its main functions are to bring attention to the proper biosphere reserve authorities about specific needs and problems of concern to the inhabitants, and to be a part of the solutions; to ensure the active participation of the inhabitants in implementing the conservation and development roles in the reserve, and to work closely with the Board of Directors to develop and implement models of development that may benefit the populations that surround the biosphere reserve, to enhance the possibilities of sustaining the currently low demographic pressure in the reserve.

Halffter (1984) considers the local populations as one of the most important components of a biosphere reserve. In developing countries, they may be the difference between failure or success.

We believe the Council of Representatives for the Biosphere Reserve of Sian Ka'an provides the local populations with a well-defined structure to participate actively in the administration and management of the reserve. It may prove to be a welcome innovation for biosphere reserves in Mexico.

The Technical Coordination Committee is presided over by a chosen academic institution (currently CIQRO) and includes recognized members of the academic community. It reviews proposals; evaluates the results of all academic programs in the reserve; advises the Director of the Reserve on all matters related to research, monitoring, education and management; and coordinates all such activities.

We differ from Halffter's (1984) idea to give the reserves administrative independence through research (academic) institutions. Based on our experience during five years of work in Sian Ka'an, we believe it is cumbersome, expensive and logistically difficult for all functions and programs to be developed by one single institution, particularly in the case of academic institutions involved in additional programs and functions. We do stress, however, the need to involve an academic institution as the coordinator of all academic and management activities in the reserve.

The Advisory Panel for the Board of Directors incoporates a representative from the following: Council of Representatives, technical coordinator, non-governmental organizations, organized community groups, and a representative from several Secretaries at the state level (i.e., Fisheries, Agriculture, Tourism, etc.). It also includes a representative from the University of Mexico and a representative from the Institute of

Anthropology and History. Future members, who must be approved by the Board of Directors, may include a representative from MAB-Mexico, other academic and governmental institutions, and members of the scientific community. The main function of the Panel is to serve as an advisor to the Board of Directors on all matters related to the Biosphere Reserve of Sian Ka'an.

We regard biosphere reserves as the most advanced models of conservation. Their concept, dynamics and functions may also make them ideal living laboratories, where the apparent dichotomy between conservation and development may find a point of balance for the well-being of mankind.

Acknowledgements

We would like to thank Dr. Gonzalo Halffter for his decisive support throughout the creation of Sian Ka'an; Bill Gregg for his support and friendship; and the National Council on Science and Technology, SEP, SEDUE and the State Government of Quintana Roo for their financial support and vision. We also thank Sebastian Estrella-Pool, Director of the Biosphere Reserve of Sian Ka'an, and Miss Joanna Green for the translation of this document.

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BIOSPHERE RESERVES AND THE CONSERVATION OF TRADITIONAL LAND USE SYSTEMS OF INDIGENOUS POPULATIONS IN CENTRAL AMERICA

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ABSTRACT: The remaining extensive tracts of tropical rainforest in Central America are also the territory of indigenous groups which maintain their traditional stewardship of the earth and its resources. These forests and indigenous cultures are currently threatened by development projects, commercial enterprises, uncontrolled colonization and military actions as well as internal influences that are forcing a transition on the indigenous societies. National governments have designated portions of these forests as biosphere reserves: the Rio Platano Biosphere Reserve in Honduras, La Amistad (Talamanca) Biosphere Reserve in Costa Rica and the Darien Biosphere Reserve in Panama. The application of this management category is demonstrating the connection between the conservation of representative samples of biogeographical provinces and harmonious man/land relationships, and provides opportunities for scientific research and monitoring, education and training, and regional cooperation. Nevertheless, several issues remain to be resolved: the conservation objectives versus the indigenous concerns for legal possession of their traditional lands, rights to natural resources, and cultural autonomy. These issues may be resolved through a fuller participation of indigenous communities in decisions which affect their land and resources, cooperatively developed technical assistance and training, as well as programs designed and administered by indigenous communities. All efforts in biosphere reserve management with indigenous peoples must recognize their traditional stewardship, knowledge and cultural investment in sustainable development.

KEY WORDS: Central America, indigenous peoples, biosphere reserves, traditional land use.

* * *

Editor's Note: The following remarks by the leaders of the Kuna and Embera Tribes in Panama were given to introduce the paper by Houseal and Weber, and reflect their particular understanding of the biosphere reserve concept.

Declaration of Aurelio Chiari
Kuna Tribe, Panama

I am a messenger who brings greetings to you from the Kuna nation. In front of this assembly I wish to say the following:

For the Kuna culture the land is our mother, and all living things that live on her are brothers. In such a manner we must take care of her and live in a harmonious manner on her; because the extinction of one living thing is also the end of another.

We preserve the forests because for us they are a pharmacy where our medicines are stored; they are a refrigerator because they keep our meat fresh; they are a store for construction materials because we obtain materials for our houses and boats from them. Some are also sacred and we must defend our religious beliefs.

The concept of a biosphere reserve, even though we do not have this term in our society, has been with us since the existence of our culture. The worry that my people have always had, about the strong pressures of deforestation, has created the impulse to plan [for] the adequate use of the resources. We have done this through the Kuna Wildlands Project, which has prepared a management plan and is now implementing it.

I will be the messenger to the Kuna congress about the international concern shown here, and I will tell them we are not alone in our efforts.

* * *

Declaration of Daniel Castaneda
Embera Tribe, Panama

On behalf of our people, the Embera, I would like to thank Drs. William Gregg and Stanley Krugman for this opportunity to speak. We send you our warmest fraternal greetings.

We are a people of 12,000 who live in the easternmost province of the Republic of Panama near the Colombian Frontier who collectively possess approximately 410,000 hectares of land for our traditional use, which has recently been recognized by a national law in 1983.

Today you speak of the Man and Biosphere Reserves. This is a concept which has been known to us for thousands of years.

Nature, for us, is sacred. Nature is power, nature is life, nature is love and nature is health. Our people therefore love nature and respect it as our mother.

I hope that all world leaders and the participants of this Congress share our belief that the conservation of nature is the most important of human activities.

Our people depend almost entirely on nature for our medicine, food, and materials for construction, all of which in turn depends on the continued existence of the forest.

We hope that you think deeply about the importance of nature conservation to our people, as well as to all people of the world.

* * *

Introduction

The remaining extensive tracts of tropical rainforest in Central America are also the territory of culturally diverse indigenous groups which maintain their traditional stewardship of the earth and its resources. These peoples maintain a spiritual relationship with Mother Earth; their cultures are intimately related to their lands and resources. They conserve them as an integral system, ranging from sacred areas with little or no access at one extreme to intensively managed land uses at the other. Their subsistence patterns are directly tied to their historical and sustainable use of renewable natural resources: hunting, fishing and gathering still provide them with food, medicines, construction materials, transportation, and cash income. Sophisticated agroforestry schemes are utilized which combine permanent tree crops with annual cultivation as well as wildlife husbandry and wild forest enhancement techniques. These people represent an immense store of knowledge about the ecology and appropriate management of tropical forest resources.

Over the past decade, several nations in Central America have designated portions of traditional indigenous lands as biosphere reserves. These include the Rio Platano Biosphere Reserve in Honduras, territory of the Paya and Miskito peoples; the La Amistad (Talamanca) Biosphere Reserve in Costa Rica, which includes Bribri and Cabecar indigenous lands; and the Darien Biosphere Reserve in Panama, land of the Kuna, Embera and Waunan people (Fig. 1). Four other areas merit consideration for designation as biosphere reserves: the Peten of Guatemala and Belize with the Maya people; the Bosawas of the Miskito and Sumo peoples in Nicaragua; the proposed La Amistad International Park in Panama, territory of the Guaymi and Teribe peoples; and Kuna Yala, land of the Kuna nation on the northeast coast of Panama.

Challenges

Both the remaining tropical forests and the indigenous cultures which depend upon them are threatened by a variety of adverse pressures. These include:

- National Development Projects: Hydroelectric dams and transmission corridors, oil pipelines and refineries, and road construction. For example, the Honduran government has recently obtained financing to extend a forest extraction road into the Olancho Province, within a short walk of the headwaters of the Rio Platano Biosphere Reserve, opening the area to lumbering and colonization of traditional indigenous lands.

- Commercial Enterprises: Cattle ranching, agricultural plantations, logging and mining concessions. The penetration of the Inter-American Highway into the Darien Province of Panama created a radical change from a historical riverine transportation system to a terrestrial one and has simulated investors to exploit the lumber and mineral resources, as well as to expand cattle grazing.

- Immigration: Landless peasants, refugees or land speculators. The uncontrolled colonization and massive deforestation on the boundary of the Kuna Yala Reserve lands in Panama prompted the Kuna to initiate their own protected areas project and to seek biosphere reserve status.

- Military Actions: War, joint military maneuvers and repression impact upon the biosphere reserves. Sections of the Rio Platano will be colonized as several thousand Misquito indigenous peoples who have fled Nicaragua seek new forest lands to resettle.

These activities are implemented with approval of the national governments and are often financed through bi- and multi-national assistance agencies, multinational corporations, commercial banks and military organizations. In general, government planners and the public hold the mistaken impression that the forested lands of the indigenous groups are sub-utilized and require earnest exploitation by more industrious people. There is no justification of indigenous rights because their resource use is not being recognized or incorporated into the national economy. The basic attitude towards the indigenous peoples has been that they should abandon their subsistence practices and assimilate into the dominant society.

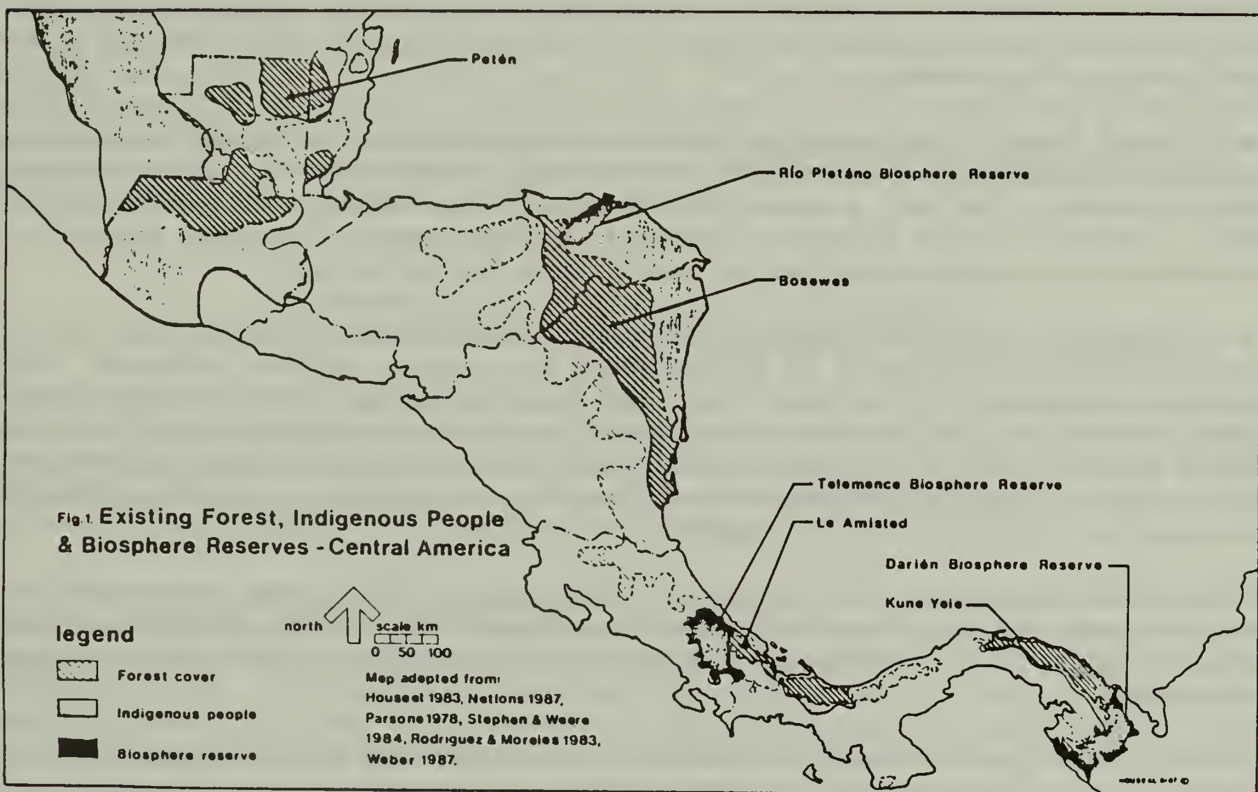

Figure 1. Existing forest, indigenous people and biosphere reserves, Central America.

These external influences are not the only challenges facing the indigenous peoples' traditional land use patterns. There are other complex factors at play within the indigenous cultures themselves. They include:

- Changes in traditional settlement patterns: With greater indigenous population growth and the occupation of the surrounding lands by members of outside societies, there is increased demand on existing territorial lands and resources. In the Darien Biosphere Reserve, the Embera, who traditionally maintained a dispersed riverine settlement pattern predicated on the ability of a family to move to less populated rivers if an area became overexploited, are now finding that this migratory mechanism is limited by the competition for lands by immigrating latino colonists, as well as Embera and Waunan colonists from Colombia. In order to adapt to this situation, the Embera and Waunan are forced to alter their settlement and land-use patterns with wide-reaching impacts on their traditional society.

- Changes in traditional economies: The desire for cash exchange and the relative availability of modern technology has sometimes led to local over-exploitation of natural resources or the disruption of traditional family roles as the men migrate to regional labor markets or the women become significant cottage industry earners. In the western sector of Kuna Yala, there is an overharvest of lobster and conch to supply visiting tourist cruise ships, and at the same time the Kuna women devote their time to the manufacture and sale of "molas" to the tourists.

- Changes in traditional education: With nationally prescribed curricula in indigenous community elementary schools, children are learning the language and culture of the dominant society, often with a proportional decline in the cultures' oral traditions. To obtain a secondary school education, indigenous children must of necessity migrate to cities where the connection with their cultural group is further severed.

- Changes in traditional political organization: The indigenous peoples have had to adapt their tribal governments to accommodate the national political structure. The hierarchial relationship to the nation state may cause disruption in the structure of the indigenous societies. The Embera of the Darien, who are an egalitarian society with no tradition of a representative political system, have over the past twenty years needed to unite and fight for the establishment of their territory, in response to a commonly shared perception that they were losing their rights.

All of these influences do not signify the disappearance of indigenous cultures, but do indicate a need for them to modify their subsistence way of life, combining their traditional ways with new techniques in a dynamic manner that enhances their cultures and economies.

For Central American biosphere reserves to be successful in the conservation of traditional land use systems, the challenge is this: to recognize the indigenous peoples' rights to their land and resources on which their cultural lifestyles depend; to enable them to manage their resources according to their traditions; and to participate effectively in decisions that affect their lands and surface, subsurface and marine resources. This will require the enlightened participation of conservationists, national policy-makers and development planners, scientists, educators, and the indigenous peoples themselves in a joint approach to the establishment and protection of biosphere reserves, design of appropriate scientific research and monitoring efforts, innovative education and training, and locally defined development of traditional economies.

The Opportunities

During the coming decade in Central America, there exists an opportunity to establish biosphere reserves as models of conservation and development in the region. Two factors are principally responsible for this situation:

- The international community has been partially successful in introducing the need for conservation in the development process, and has produced a response among the Central American governments. The World Conservation Strategy, Folio on Indigenous Peoples and Conservation; the Panama Declaration of the World Council of Indigenous Peoples; the Recommendations of the World National Parks Congress,the World Bank Policy on Wildlands and on Indigenous Peoples; USAID's Biodiversity Program; and substantial private sector support, are all making a substantial impact. Increasingly, national governments are seeking viable alternatives for sustainable economic development which can be adapted to the particular socio-economic and environmental characteristics of their often diverse sub-regions. Respect and understanding of the traditional land use systems of indigenous peoples are increasing as the inappropriate practices imported from other ecological zones are failing.

- At the same time, indigenous groups are growing more aware of the imminent threats to their lands, natural resources and cultural survival, and are moving rapidly towards better political organization and action. This has engendered an increase in their cultural pride and confidence to maintain a dialogue with the national and international agencies and groups directed towards the equitable resolution of these issues. The biosphere reserve provides a forum to explore new concepts of conservation, research and monitoring, education and training, and cooperation.

Fostering the Participation of Indigenous People in Conservation and Management Decisions

The success of the biosphere reserves in Central America will ultimately depend on how well the local peoples have understood and accepted them. The indigenous groups have readily grasped the concepts of the Biosphere Reserve Project because of the similarities with their cultural view of the world. Now there are a number of actions that can be taken to encourage their continued participation:

- First, we must <u>define the process</u>: The planning and management of biosphere reserves should be defined with indigenous residents of the area. In many cases, the national government's "decision-making process" may have to be adapted to the indigenous model. The indigenous approach to problem-solving may be more time consuming, but it is often more democratic and produces more successful results than something decided upon in the nation's capital with no local involvement; or still worse, in a donor country capital, several thousand miles away.

- Second, we must <u>build confidence</u>: The first stage in Central America has been to assist the indigenous peoples in the protection of their land against external impacts. There is a common denominator between conservationists and indigenous people- halting deforestation and environmental degradation. Both can invest successfully in the effort and learn about each other in the process. An initial grant from the Inter-American Foundation to the Kuna wildlands project built the Kuna's administrative and technical confidence by signaling that the international community was concerned and would assist their cause.

• Third, we must focus on local issues: As with most societies, indigenous peoples are concerned about their social and economic development and its relationship to the natural resource base.

• Fourth, we must build institutions: The Kuna wildlands project experience has demonstrated it is imperative that the indigenous people become the long term managers of biosphere reserves established on their traditional lands. If local capacity does not exist, efforts should be made to build it through training. When outside researchers or technical advisors are required, local counterparts should be a requirement to ensure a culturally acceptable product and to provide for future exchange of information in both directions. Indigenous residents should assist in the design of management programs, and should implement them. Locally employed personnel, local administration of funds, identification of needed resources, and the development of a local capacity for the long term financial self-sustainability of biosphere reserve operations are all components in institution building.

Conclusion

The indigenous residents and biosphere reserve managers are potential allies and can collaborate to conserve natural resources and traditional land uses. The biosphere reserve concept has the potential to provide important regional forums to study resource conservation and educate others, while providing the opportunity for cultural growth and development. A key ingredient in this process is the recognition of the indigenous groups' traditional knowledge and cultural investments in sustainable development.

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BIOSPHERE RESERVES OF CENTRAL AMERICA: A CRITIQUE[1]

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ABSTRACT. Three large wildlands have been declared biosphere reserves in Central America. Each of these reserves has received World Heritage status as well. These three reserves are described and evaluated in terms of their potential to fulfill biosphere reserve objectives. All three reserves met MAB objectives in a general sense at the time of their designation, for they each protect large representative ecosystems, and each are inhabited by groups of indigenous (Amerindian) people living in a sustainable fashion with their environment. The huge task for managers is to make these areas relevant and useful to the non-indigenous people who are rapidly destroying forests near and in these biosphere reserves.

KEY WORDS: Biosphere reserves, Central America, rain forest, Amerindian people.

Introduction

Central America is well on its way to building an extensive system of biosphere reserves. Three large biosphere reserves were designated in the late 1970s and early 1980s: the Rio Platano in Honduras, Darien in Panama, and La Amistad in Costa Rica (Figure 1). More recently, the Cordillera Volcanica Central in Costa Rica received biosphere reserve status. Some twelve other areas wait in the wings, having been identified as potential candidates.

It is worthwhile at this time to summarize biosphere reserve efforts in the region by briefly describing the three largest and longest existing reserves, outlining their management directions, and identifying the major threats and obstacles they must overcome to reach these objectives. Based on this survey, some conclusions and recommendations concerning biosphere reserve management in the region can be formulated.

A biosphere reserve is a land management category distinct from a traditional national park or equivalent protected area. Though the biosphere reserve concept is still evolving, Batisse (1986) succinctly argues that all biosphere reserves have three basic roles: a conservation role, a development role, and a logistical (research and training) role. All biosphere reserves are obliged to carry out these roles in some integrated fashion. Emphasis on each role will vary from one reserve to another, depending on the ecological and sociological environment of each reserve, and on the human and financial resources

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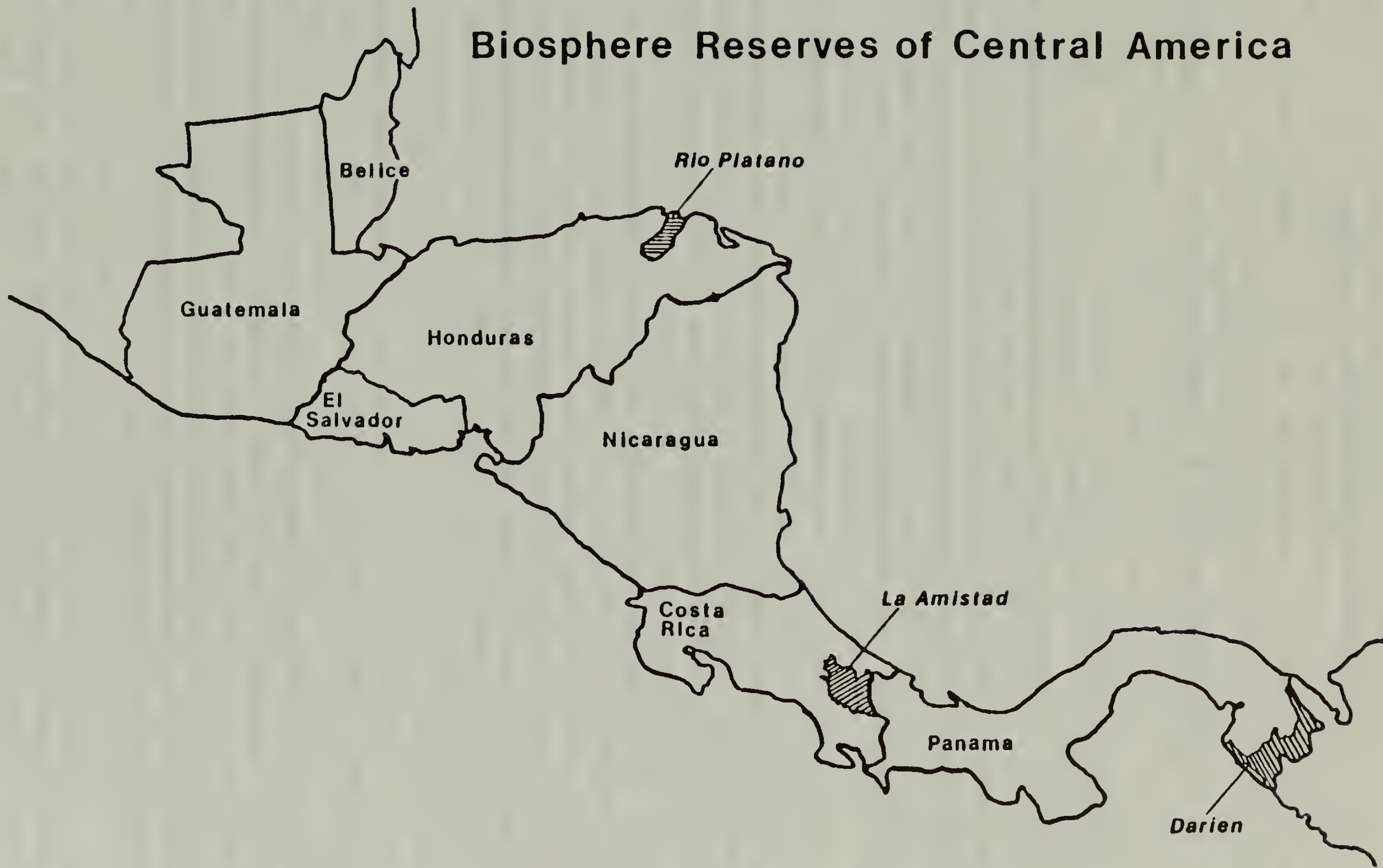
Biosphere Reserves of Central America



available to reserve managers. However, as Batisse makes very clear, it is the "combined presence [of these roles] that is characteristic of the project" (Batisse 1986). This triad model forms the basis for the following analysis of existing and proposed biosphere reserves in Central America.

Rio Platano Biosphere Reserve, Honduras

DATE ESTABLISHED: UNESCO designation in 1979. Legally decreed a biosphere reserve on 15th of August, 1980, by the military junta ruling Honduras at that time.

LOCATION: In the Mosquitia region of Honduras, bounded on the north by the Caribbean Sea.

ALTITUDE: Sea level to 1326 m.

AREA AND SHAPE: 525,000 ha in a north-south rectangle 150 km long by 50 km wide.

PHYSICAL FEATURES: The entire watershed of the Platano River forms the reserve core. From its headwaters in rugged mountains the river runs north, in places dropping in long falls and at one point--El Subterraneo--disappearing from view beneath huge basalt boulders. The final third of its course runs over a nearly flat coastal plain.

BIOLOGICAL RESOURCES: This reserve is the only large protected area in the famous Mosquitia region of Honduras and Nicaragua. (Note, however, that Nicaragua's Saslaya National Park, presently just 11,000 ha, may be greatly enlarged in the future.) The coastal environments include freshwater lagoons harboring Caribbean manatee (*Trichechus manatus*), mangrove forests supporting crab and shrimp populations, and sand beaches where four endangered species of sea turtles nest. Gallery forest along the Platano grades into rain forest in the lowlands and dense cloud forest in the mountains. This large expanse of unbroken tropical forest harbors a huge variety of plant species and a wealth of animal species, including jaguar (*Felis onca*), ocelot (*F. pardalis*), puma (*F. concolor*), margay (*F. wiedii*), jaguarundi (*F. yaguaroundi*), tapir (*Tapirus bairdii*), Central American otter (*Lutra longicaudis*), harpy eagle (*Harpia harpyja*), scarlet and great green macaws (*Ara macao* and *Ara ambigua*), American crocodile (*Crocodylus acutus*) and brown caiman (*Caiman crocodilis fuscus*).

ARCHEOLOGICAL RESOURCES: A number of archeological sites have been discovered in the reserve. Rock carvings are found along the Platano in its upper reaches.

HUMAN POPULATIONS: When the reserve was first established in 1979, some 2,500 people lived within its boundaries, mostly Miskito Indians. These people, with a few Paya Indians as well, still live along the coast and lower stretches of the Platano. While many Miskito men work as divers for commercial lobster boats operating from the nearby Bay Islands, families still maintain their farm plots along the Platano River, growing corn, fruit and other crops in the fertile floodplain soils.

Unfortunately, beginning in the early 1980s, the southern end of the reserve was logged by Honduran lumber companies and subsequently invaded by mestizo settlers, migrating from the southwest provinces of Honduras. It is estimated that some 6,500 people now live in the reserve's southern end, and that 10 to 20% of the original forest area has been cleared.

MANAGEMENT DIRECTIONS: The first management plan, formulated by the Honduran Renewable Natural Resources Department (RENARE), focused on working with the Amerindians on the coast, and had involved these people to a significant extent in reserve planning. With funding from WWF-US, an administration building and bunkhouse were built near the river mouth, and an administrator and several Miskito rangers were hired.

The crisis in the reserve's southern zone was discovered in 1985. Conservationists had anticipated problems to some extent, and the IUCN had placed Rio Platano on their list of most endangered wildlands in 1984. Little action was taken, however, until January, 1987, when representatives from RENARE, the Honduran Forestry Development Agency (COHDEFOR), the non-profit Honduran Ecological Association (AHE), the Honduran Logging Association (AMADHO), university faculty and other interested parties met for an emergency wildlands planning workshop in Olancho, Honduras. With the assistance of wildlands planning staff from the Tropical Agriculture Research and Teaching Center (CATIE) in Costa Rica, a two-year operational plan (AHE 1987) was drawn up that focuses primarily on stabilizing the deforestation front. Specific activities called for include:

- The transfer of primary responsibility for the reserve from RENARE to COHDEFOR, because of the greater management experience and standing in the government hierarchy held by the latter agency.

- Construction of a reserve headquarters in the southern zone, hiring of a professional-level reserve director and assistant director, to be paid through AHE and "loaned" to COHDEFOR. RENARE staff will continue their work in the northern zone.

- Resettling those people (some 2,800 in number) located in the actual core zone of the biosphere reserve, with the assistance of the Honduran Agrarian Institute (INA).

- Initiating an array of development projects with the approximately 12,700 people who now live either inside the reserve buffer zone or just outside it. The activities include an environmental education program, agriculture extension and model farm projects to encourage crop diversification and appropriate land use, introduction of green iguana and other small animal farming, and pilot forestry programs for firewood and construction materials.

- Initiating a research program, to be coordinated by a reserve research director. Investigation will focus on floral and faunal inventories, potential land-use capacity in settled areas, and raising of small native animals in captivity.

Needless to say, achieving all these objectives will require many people and a great deal of equipment, all operating under difficult conditions of terrain and access. The critical zone lies some 5 hours from Tegucigalpa by road, and in certain seasons access may be cut off by washouts and flooding. There is no running water or electricity in the crisis area.

Two-year funding requests to USAID, WWF-US, UNESCO, plus in-kind services from Honduran agencies, total (in U.S. dollars) $1,155,441. Nearly 60% of this is requested from USAID. WWF-US, UNESCO, the New York Zoological Society, and the Rockefeller Foundation have all provided some funding in the last several years, but much more is now needed.

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La Amistad Biosphere Reserve, Costa Rica

DATE ESTABLISHED: Designated a biosphere reserve in 1982. Contains indigenous reserves, national parks, national forest and other areas, all given protected status at various times over the last 20 years.

LOCATION: On the Costa Rican-Panamanian border. Contiguous wildlands on the Panamanian side may eventually be joined to the Costa Rican reserve, forming an internationally-managed biosphere reserve. Note that "amistad" means "friendship" in Spanish.

ALTITUDE AND RAINFALL: 100 to 3819 m; 2000 to 7000 mm.

AREA AND SHAPE: Over 500,000 ha, a blocky rectangle.

PHYSICAL FEATURES: The rugged Talamanca Range of nonvolcanic mountains runs the length of the reserve. Large faults cross the area, which together with roaring streams have created an intensely dissected topography. The peaks of the highest mountains supported glaciers during the Pleistocene, and cirques and moraine features persist.

BIOLOGICAL RESOURCES: The range of temperature, rainfall, slope, exposure, and soils results in a variety of plant communities, from premontane rainforest up through cloud forest and temperate oak woods to alpine meadow-scrub (paramo). Eight of Costa Rica's 12 Holdridge life zones are represented in the reserve. Cloud forest is the dominant vegetative formation, characterized by large to medium-sized trees covered with orchids, bromeliads, mosses and lichens. Animal life is correspondingly diverse as well. Rare and endangered mammals that inhabit the reserve include all six Central American cat species, the giant anteater (*Myrmecophaga tridactyla*) and the tapir (*Tapirus bairdii*). Bird life is also very diverse with over 400 species listed, including the resplendent quetzal (*Pharomachrus mocinno*).

ARCHEOLOGICAL RESOURCES: Two major archeological regions are represented in the reserve, and nearly 200 burial and settlement sites have been discovered.

HUMAN POPULATIONS: Ringing the core wilderness area are five indigenous reserves, occupied by two distinct Amerindian cultures, the Bribri and the Cabecar. Precise population counts are difficult to make, but estimates range between 8,000 to 12,000 people. Both groups practice shifting agriculture, keep pigs and chickens, and hunt. The Bribri are the more acculturated group, and most would like improved access to markets and goods. The Cabecar are less tolerant of Western ways.

MANAGEMENT DIRECTIONS: This biosphere reserve is unique in the region, being a composite of a dozen contiguous management areas that continue to operate largely under their original management schemes. Thus, the two national parks and two biological reserves that form the reserve core are managed by the National Park Service; the indigenous reserves are managed by their resident communities and by the National Commission of Indigenous Affairs (CONAI), while the Forest Service (DGF) watches over national forest lands and wildlife refuges. Finally, the private non-profit Organization for Tropical Studies (OTS) maintains a botanical garden/research station that has also been included in the biosphere reserve.

Perhaps the most noteworthy "product" of this biosphere reserve to date has been a largely successful effort to obtain the active participation and support of these diverse organizations in reserve planning. This effort has recently culminated in a 280-page strategy document (Torres and Hurtado de Mendoza, eds., 1988); the eleven authors included sociologists, geographers, an anthropologist, an historian, a forester, an environmental planner, and a biologist.

Specific management directions gleaned from the plan include:

- Management coordination will be centered in the Ministry of Natural Resources. A Coordinating Council made up of administrators of each protected area will meet on a regular basis, including Amerindian tribal leaders. A Scientific Advisory Council will be created to coordinate and encourage research in the reserve.

- The critically important role of the Amerindian communities is recognized throughout the plan. Many proposed activities will have the effect of strengthening the ability of these communities to control their traditional lands, and to develop and change in ways and at a pace of their own choosing. Clearly, the hope is that these people will continue the sustainable hunting, agriculture, and forestry practices they use today.

- In addition to the core (parks) and traditional use (Amerindian reserves) zones, zones of rehabilitation, multiple functions, and cooperation are identified. Land use by the predominately nonindigenous populations in these zones includes nonsustainable practices such as forest clearing, cattle ranching, and year-round hunting. The plan calls for agricultural extension and credit, environmental education, and demonstration farm projects in these areas. The National Park Service and OTS have already begun small environmental education programs in the critical Pacific slope area.

- Research will focus on ecosystem monitoring, faunal and floral surveys, continued archeological exploration, and studies of indigenous land use practices.

The most immediate threat to reserve lands is the expanding population of campesino farmers and ranchers on the Pacific slope. Illegal settlement of indigenous land in that area has become routine; some of these lands will be purchased back and returned to indigenous control, but it is likely that in other cases zone boundaries will simply be redrawn.

In the future, official development schemes may endanger the integrity of the biosphere reserve. It is estimated that 50% of Costa Rica's hydroelectric generating potential is located within the reserve, and 20 potential sites for dam construction have been identified by the government. Fortunately, most of these sites are located outside of the reserve, and will use the reserve simply as a "forested reservoir." Coal and oil exploration is also underway in the area. Environmental impact statements will be required of any large development projects, and careful cost-benefit studies will be carried out.

To date, in fact, the Costa Rican government seems genuinely supportive of maintaining the reserve core forever wild, recently announcing that it would not permit construction of a proposed oil pipeline across the reserve. This decision prompted the IUCN to take Amistad off their list of most-endangered wildlands.

As for present budget requests, information is not available. WWF, UNESCO, and the Donner Foundation have all provided funding in the past and it appears likely they will continue to assist in the future. Both the Nature Conservancy and Conservation International have become involved in fundraising for this area recently.

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Darien Bisophere Reserve, Panama

DATE ESTABLISHED: Declared a national park in 1980, and designated a biosphere reserve in 1983.

LOCATION: The eastern end of Panama, along the Colombian border.

ALTITUDE: sea level to 1,875 m.

RAINFALL: 3000 to 5000 mm per year

AREA AND SHAPE: 575,000 ha. Irregular in shape (see map, Figure 1).

PHYSICAL FEATURES: A diverse area, with slow brown rivers, clear rocky streams, forested mountains, and ocean beaches. The Darien Range crosses the reserve in the north, while Cerro Pirre peaks and ridges rise near its center and run south to the Colombian border.

BIOLOGICAL RESOURCES: The flora of Darien has been lauded for years by tropical botanists as one of the most diverse in the world. Botanical expeditions to the highlands have found a remarkably high degree of endemism; this is in addition to the high diversity found in the large areas of intact lowland tropical rainforest that occur in the reserve. Mangrove and gallery forest areas are also represented.

Animal diversity is high as well. Fifteen endemic bird species are known from the Darien highlands. Total bird counts number between 449 and 652 species, depending on whether totals for coastal and migratory birds are added to those for resident birds. Some 132 mammals have been observed, including the unusual jungle dog (*Speothus venaticus panamensis*), five *Felis* spp., and tapir (*Tapirus bairdii*).

ARCHEOLOGICAL RESOURCES: No archeological sites have been discovered in the park.

HUMAN POPULATIONS: Approximately 2,325 people live in a number of small settlements inside the Darien Biosphere Reserve, including 1,675 Embera and Waunan people (both called Chocos by Westerners), 250 Kuna Indians, and 400 blacks and mestizos. All these people are primarily subsistance farmers, supplementing their crops with game, fish, and wild plant products. Approximately 27,000 people live within 10 km of the reserve's borders, 11,000 on the Panamanian side, and 16,000 in Colombia. Most of those on the Panamanian side are "darienitas," blacks descended from escaped slaves. These people live concentrated in and around several small towns, with stores, airstrips, and paved streets---but no connection by road to the rest of Panama. Travel throughout the area is by boat or on foot. An influx of mestizo settlers is entering Darien Province; as in Honduras, these people are coming from the opposite end of the country searching for forest lands to clear.

MANAGEMENT DIRECTIONS: The Renewable Natural Resources Institute (INRENARE) of the Panamanian government has full management responsibility for the area. With aid from WWF-US, and with technical assistance from the Panamanian non-profit organization, the National Association for the Conservation of Nature (ANCON), two guard and visitor lodges have been built in the reserve, and a park superintendent and indigenous guards hired.

In addition, a management plan (INRENARE, in press) has recently been completed and is circulating for review. Though Darien National Park was simply redesignated a biosphere reserve with no change in its boundaries, the management plan does call for zoning the reserve into core conservation areas, cultural zones, and a special use zone (proposed corridor of the Panamerican Highway). It also defines a 10 km "zone of influence" around the reserve on the Panamanian side.

Activities planned for each zone include:

- Research and monitoring in core zones. Subsistence hunting by indigenous people will continue in these areas.

• Research on indigenous farming, fishing, and hunting practices in the cultural zones. In addition, the plan suggests that a nature and cultural tourism program be created in these zones, if the indigenous people will benefit from such development.

• An environmental education program will be initiated in the zone of influence, and a land use and socioeconomic survey will be carried out. The goal of this survey will be to determine what extension and rural development programs are most needed in the area. According to the plan, extension efforts will likely emphasize diversification of crops for consumption and sale, introduction of green iguana and other small animal farming, and fish culture. Reserve managers will help coordinate efforts of the Health Ministry, Farming Development Ministry, Ministry of Education, and other entities concerned with development in Darien Province.

Threats to the reserve identified in the plan include the influx of campesinos into the Province from distant parts of Panama, with the resulting destruction of buffer forest and possibly of reserve forest as well. Demarcation of reserve boundary lines is presently underway. Another threat is mining: five gold mining concessions in the reserve have been granted by the Panamanian government, all without consulting INRENARE. Access to the mines is presently possible only by air, but further development may entail road construction. Finally, there are periodic bursts of enthusiasm for completing the Panamerican Highway; presently, the road ends in Panama about 30 km from the reserve boundary.

The five-year proposed budget (in U.S. dollars) is $1,756,221. WWF-US and UNESCO have provided funding in the past, and are expected to do so in the future, perhaps aided by other donors as well.

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Discussion

The three Central American wildland areas initially chosen for designation as biosphere reserves clearly share several important characteristics. First, they are all located in large, remote wilderness areas, among the last such areas left on the Central American isthmus. If their extensive dense forest zones can be maintained intact, these three reserves alone will make an enormous contribution to preserving the natural genetic heritage of Central America (see Lovejoy 1983; Vaughan 1983). Certainly the conservation role of biosphere reserves is well satisfied by these "crown jewels" of Central American wildlands.

Second, largely because of their historical inaccessability, all three reserves are home to indigenous groups, who still speak their native languages and maintain most of their traditional practices and beliefs. Many of the actions called for in the reserve plans will enhance the ability of these groups to maintain indefinitely their traditional ways, thereby conserving what remains of the region's original cultural heritage as well. The special participatory management required for such areas fits very well into biosphere reserve philosophy (Houseal et al. 1985; Brownrigg 1981).

Third, though these areas certainly remain off the beaten track, the "outside world" is nonetheless quickly arriving. To the extent that biosphere reserve status and accompanying international recognition enhance the sanctity of an area, these reserves have been designated in the nick of time. All three areas have also received World Heritage Site designation by UNESCO, perhaps further strengthening their protected status.

Much more to the point, though, the needs of the people living and settling near these reserves have been addressed in the reserves' management plans. In the case of Rio Platano Biosphere Reserve, the first management plan was scrapped entirely, and an action-orientated "operational plan" was put in its place, when addressing the needs of campesinos became so important to that reserve's survival. For Darien and La Amistad, the deforestation fronts had already arrived when their first management plans were written.

The challenge now, of course, is to bring these finely constructed plans to life. Perhaps the most basic obstacle that must be overcome in this regard is isolation. The same splendid isolation that has kept these areas so wild, that has provided refuge to the last Mesoamerican indigenous groups, will naturally make the ambitious programs of integrated rural development called for in the plans doubly difficult. Sustaining programs of environmental education, agricultural extension, rural health care, road and bridge improvements, and improved access to markets is bound to be more challenging and costly in distant, isolated areas. For example, until WWF-US paid for the tickets, no high-level INRENARE official had visited Darien Biosphere Reserve, though it had been a national park for several years prior to designation. Travel to Darien and to the northern zones of Rio Platano is possible only by air, and remains prohibitively expensive for government conservation staff. Simply demarcating and patrolling the protected-zone limits of these large reserves is a formidable task, though hiring Amerindian and other local people as wardens is an effective measure.

Indigenous people may also be willing to serve as guides and assistants to visiting investigators, but researchers also need reasonably easy access and some on-site laboratory facilities for most long-term studies. While each of these areas has been visited by scientific expeditions to conduct initial floral and faunal surveys, only La Amistad Biosphere Reserve presently supports any ongoing research efforts. And this one project, a long-term forest growth and yield study, is an exception that proves the rule, for it is located precisely where the Panamerican Highway comes within a few kilometers of the reserve boundary.

It is important to recognize these obstacles when the developmental and logistical (information generating) roles of these three biosphere reserves are considered. Achieving the essential biosphere reserve objectives of determining and divulging more sustainable uses of local natural resources with and for the local populations is going to require long-term, generous support from both national and international sources. The two-year U.S. $1,000,000+ budget requested for Rio Platano is an indication of the magnitude of the challenge.

Conclusions

Two general conclusions are possible following this survey. First, the biosphere reserve designation is being interpreted by Central American conservationists as an independent, new protected area category, with a management focus quite distinct from a traditional national park or equivalent reserve. While perhaps none of the present areas can be singled out as a model biosphere reserve, in their new management plans they all possess the necessary elements called for by Batisse (1986).

Second, in spite of their novel approaches and international recognition, biosphere reserves in Central America are destined to face the same challenges of other protected area categories, including scarce funding which translates into lack of equipment and trained staff. These reserves will suffer poaching, logging, and incursions by squatters. Government-sponsored development projects may threaten them in the future. The destruction presently underway in the Rio Platano Biosphere Reserve and the deforestation front building near Darien Biosphere Reserve teach an important lesson: the "zone of influence" of reserves in Central America may be no less than the entire nation in which they are located! In both cases, campesino families are coming from the opposite end of their countries, where there is no longer any available land, to the provinces that still possess "el monte," virgin forest.

Beyond national considerations, it must be recognized that regional conflicts can have a great impact on conservation in Central America. Some Hondurans argue that logging companies first entered the Rio Platano Biosphere Reserve because they were barred from cutting timber in the forests bordering Nicaragua where the anti-Sandinista "contras" exercise their strange form of territorial sovereignty (COHDEFOR staff, pers. comm.). And if conflicts intensify, refugees fleeing from battle zones will likely head for unpopulated areas such as parks and reserves in search of land. Already, in fact, a group of Miskito Indians fleeing Nicaragua in 1982 was resettled in the northern zone of Rio Platano Biosphere Reserve by the UN High Commission on Refugees. This same group was successfully repatriated by the Commission in early 1987.

Certainly, the future of Central American biosphere reserves will not depend solely on their ability to fulfill the ideal triad model described by Batisse. Rather, it will depend to a great extent on how well the nations of the region address a whole gamut of problems in the coming decades, including resolving armed conflict and coming to grips with issues of land and population.

Recommendations

1. As mentioned above, Rio Platano Biosphere Reserve is already on the IUCN list of most threatened wildlands. However, IUCN, WWF, and other conservation organizations aware of the seriousness of the problem should use their communications media to focus more international attention on the Reserve. At the very least, the damage to this reserve highlights the dangers of "passive" conservation. We must not rely on the historical inaccessibility of these areas to protect them in the future.

2. International development and finance organizations active in Central America should recognize that the biosphere reserve concept as it is currently evolving offers

great opportunities for creating model areas of sustainable development, simultaneously preserving huge amounts of biological diversity *in situ*. Both the World Bank and US-AID have formally recognized the importance of preserving biological diversity, and are striving to incorporate biodiversity protection into future projects. Both organizations should now be urged to target development dollars to the zones of influence and the cultural zones in and around the region's biosphere reserves, working closely with the agencies and conservation organizations managing these areas.

3. Central American conservationists must recognize that obtaining biosphere reserve designation for an area offers little in the way of guaranteed protection through international recognition or prestige. The biosphere reserve designation should be seen primarily as an obligation, involving a long-term commitment of staff, equipment, and funding. Even if US-AID and other development organizations can be convinced to help, it would be better to focus efforts on bringing existing reserves to life than to designate many additional reserves in the near future.

I do not mean to suggest that no additional reserves should be designated, however. In fact, for a number of reasons, the Cordillera Volcanica Central Biosphere Reserve (designated in February, 1988) and several of the proposed areas are likely to achieve the Batisse model both better and sooner than the three "crown jewels" described in this paper. The key is access: the Codillera Volcanica Central already has people living in and near it who are able to follow through on major biosphere reserve objectives. For this and other reasons, the CVC fully deserved biosphere reserve status. Further additions should be made with care, however, with consideration of regional conservation priorities, and with a hard realistic look at available human and financial resources by the nominating country.

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LA AMISTAD BIOSPHERE RESERVE: AN EXERCISE IN ENVIRONMENTAL PLANNING

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ABSTRACT. Environmental planning techniques were used to produce a Conservation and Development Strategy for La Amistad Biosphere Reserve in Costa Rica. A review of the outstanding natural and cultural resources highlights: biodiversity, hydroelectric potential, pre-Hispanic occupation, and contemporary Indian cultures. The planning process is described, including problem definition, data collection and analysis, strategy synthesis, implementation, and evaluation. It is suggested that the resulting document (environmental and social analyses, zoning, and action plan) can lead to integrated management of the biosphere reserve. The methodology is presented as a potentially useful technique in developing management strategies for other biospheres.

KEY WORDS: biosphere reserve, La Amistad, environmental planning, conservation and development strategy, integrated management.

Introduction

This paper describes the main features of the planning process that produced a Conservation and Development Strategy for La Amistad Biosphere Reserve. It also highlights some of the more important biophysical and sociocultural factors that were used in the analysis. The usefulness of the strategy for integrating the management of La Amistad is discussed, as is the applicability of planning methodology to other biosphere reserves.

Since the creation of the first biosphere reserve in 1976, some 70 countries have endorsed the concept and nominated 269 areas that have been incorporated into the list of biosphere reserves (Batisse 1986). In 1982, La Amistad Biosphere Reserve in Costa Rica was accepted by UNESCO-MAB, covering almost 10% of the national territory. The biosphere reserve spans the Cordillera de Talamanca, a mountainous range dividing southeastern Costa Rica into Caribbean and Pacific sectors. It is adjacent to large tracts of Panamanian forest that have been proposed for inclusion in that country's system of protected wildlands.

La Amistad includes 3 areas managed by the Costa Rican National Park Service, 2 areas managed jointly by the park service and the General Forestry Directorate, and 9 Indian communities located in 5 Indian Reservations, managed jointly by local development associations, the National Committee on Indian Affairs, and the Institute of Agrarian Development. Political jurisdictions include 3 regional administrations and 19 cantons.

The nomination and acceptance of La Amistad as a biosphere reserve was mainly based on the importance the area has for the protection of a wide range of natural resources, including an incredible variety of plant and animal species as well as strategically important hydroelectric potential. Later investigations have also shown that La Amistad protects a large number of archeological sites that provide information on settlement and land use patterns over the last 3000 years.

Biodiversity

The great diversity of plant and animal species found in La Amistad is due in large part to the range in environmental conditions, biogeographical interactions between local Costa Rican and Panamanian floras and faunas, and those of the Caribbean and North and South America. The conservation of these resources has been possible due to the physical and social situation that has limited the expansion of the agricultural frontier to peripheral areas of the biosphere reserve.

With elevations from less than 100 m to over 3800 m, and climatic regimes characteristic of both the Pacific and Caribbean slopes of Central America, La Amistad contains 8 of the 12 Life Zones present in Costa Rica (*sensu* Holdridge). A compilation of faunal range estimates (Rodriguez 1987) confirms earlier reports (Tosi 1981) to the effect that two-thirds of the vertebrates found in Costa Rica are present in La Amistad. These include most of the endangered species listed for Costa Rica: 7 of the 11 birds, 14 out of 16 mammals, and all of the amphibians and reptiles except sea turtles.

The protection offered by La Amistad is critically important for the felines and birds of prey, including the jaguar (*Felis onca*), mountain lion (*Felis concolor*), and the harpy eagle (*Harpia harpyja*), which all require extremely large territories (2000 to 5000+ km) to support viable populations (Vaughan 1983). Other important species protected in the biosphere reserve include spider monkeys (*Ateles geoffroyi*), giant anteaters (*Myrmecophaga tridactyla*), tapirs (*Tapirus bairdii*), collared peccaries (*Tayassu tajacu*), and resplendant quetzals (*Pharomachros moccina*).

Given the widespread deforestation that has occurred in Costa Rica, no other area offers the breadth of plant communities that exist in La Amistad. Significant samples of the Tropical Wet Forest and the Intermediate Zone (*sensu* Gomez) remain unaltered and are considered to be among the most diverse floristic zones in Costa Rica (Hartshorn et al. 1982, Gomez 1986).

Preliminary plant surveys carried out by personnel of the Missouri Botanical Garden, the Costa Rican National Museum, the Tropical Science Center, and the national universities have confirmed the importance attributed to the region. Of the 850+ species reported for La Amistad (Masterson 1987), 66 are considered to have special importance as endemics, species of limited distribution, or as new species. When the voluminous information collected as part of the Meso-American Flora is analyzed, these figures will increase several-fold (M. Grayum, pers. comm.). Another important aspect yet to be studied in detail is the economic potential of plant species utilized by local Indian populations.

Cultural Resources

A relatively large number of archeological sites have been found in La Amistad. They have provided valuable information on the history of occupation of La Amistad in pre-Hispanic times, and also provide the means for understanding indigenous land-use practices in southern Costa Rica and western Panama. In addition to the scientific value of these areas, several sites preserve archeological features that should attract visitors interested in the Costa Rican cultural heritage, including local residents, for whom a serious interpretive program will have to be developed.

Surface collections have yielded artifacts (pottery and stone-work fragments) which provide the basis for chronological ordering of cultural sequences for practically all of the biosphere reserve. More sophisticated remains, such as spherical stone balls, carved stone pillars, stone-lined tombs, walkways, terraces, petroglyphs and raised dwelling platforms, have permitted the assessment of trade patterns and cultural influence with other regions of Costa Rica and Panama.

Nine Indian communities pertaining to the Bribri and Cabecar nations live within La Amistad. The differing levels of acculturation and associated land-use practices strongly affect the conservation of tropical forest resources. In communities with more traditional lifestyles, an extensive forest cover is maintained. The most acculturated communities are surrounded by degraded pastures, several hours from the forest fringe. All in all, it should be noted that the core areas of La Amistad are best protected where they are adjacent to organized Indian communities.

The occupation of much of the biosphere reserve by modern indigenous cultures has an importance that should not be overlooked. In many cases, areas currently occupied coincide with sites utilized in the past, underscoring the long-term relation which has existed between these peoples and the tropical forest (Hurtado de Mendoza 1987).

Given the advanced state of deforestation in the rest of Costa Rica, the attitudes and practices that have been preserved by these groups could well be the focus of campaigns to promote a national conservation ethic. Ethnobiological research is another field which has only been partially investigated, and which could potentially yield important results. In both cases, actions should be taken before the loss of cultural identity and traditional knowledge makes the situation irreversible.

Sustainable Development: Threats and Opportunities

Conflicts in resource use exist at the local and national levels, and in varying degrees affect the integrity of the biosphere reserve. The negative effects of poor management practices are being felt by both Indian and non-Indian populations, and as a result, conservation movements are being formed within or near the biosphere reserve. To date, the combined impact of these actions is small, but as water and timber resources become more scarce, support given to these activities and their importance should grow.

The Pacific Slope presents the most difficult situation, where the advance of the agricultural frontier has led to the disintegration of Indian communities, poaching, sacking of archeological sites (M. Garcia, pers. comm.), widespread soil erosion, and very low productivity (Hartshorn et al. 1982). While political pressure and a lack of resources inhibit the enforcement of existing legislation, it remains very difficult to promote better pasture and crop management on marginal lands that have been cleared of forest cover.

On the Atlantic Slope, the local problems have been less severe, due in part to the greater cohesiveness of the indigenous population, more effective support provided by government agencies, and less favorable climatic conditions for forest clearing. Although acculturation has accompanied road development within Indian reservations, extensive areas that were formerly managed by Indians for cattle production are now giving way to secondary forest. The most serious conservation threats involve the accelerated breakdown of traditional organization caused by the illegal trade in archeologic artifacts and marijuana, and the lack of programs promoting more productive, sustainable land-use practices.

At the national level, decisions have to be taken concerning the appropriate development of La Amistad. Major projects under consideration or in early stages of implementation include coal mining, oil production, hydroelectric power generation, and a trans-isthmic oil pipeline. If these projects are undertaken, environmental studies analyzing the social and ecological impacts and the costs of mitigating them will be vitally important. The local biosphere reserve network is the ideal medium to ensure adequate analysis of the issues and timely participation of local community groups.

The Environmental Planning Process

The environmental planning process used to develop the La Amistad Conservation and Development Strategy was based on IUCN recommendations (IUCN 1981). The process includes the following interrelated steps: (1) project definition, (2) data collection, (3) data analysis, and (4) data synthesis. Two additional steps remain to be taken following approval of the planning document(s): (a) implementation and (b) evaluation.

Project Definition

Project definition was the most critical step in designing the environmental planning approach for La Amistad Biosphere Reserve. The project was defined by the environmental planning/client team by stating (1) the needs and (2) goals of all the contributing factors, and (3) the contraints on the study (short-term, intermediate, and long range).

The planning team was formed with personnel drawn from the CATIE Wildlands Program, counterparts from the Costa Rican National Park Service, and experts from the Spanish Technical Mission in San Jose. The variety of fields represented (environmental science, anthropology, geography, sociology, forestry, archeology and biology) permitted the team to deal with a wide range of complex issues.

The composititon of the project team, particularly the choice of project manager, the timing and assignment of responsibilities and tasks, and the establishment of lines of communication between field scientists, local communities, and planners were all essential to effective planning. The project definition phase provided the basics necessary to proceed with the designing of the detailed project work plan.

Data Collection

Following a preliminary review of available documentation, informational gaps were identified and the team members established priorities for data collection. The twin focuses were on information needed to clarify conservation and development issues.

Thematic maps were used to store and display much of the information that was needed. This facilitated the comparison of data covering such seemingly disparate aspects as distribution of archeological sites and life zones, or related topics such as forest cover and land use capacities.

A great deal of literature was uncovered, but it varied greatly in scope, detail and usefulness. Regardless of the conservation/development issues, certain types of information will always be required for decision-making. It was useful in our experience to organize the data into the following categories to facilitate information retrieval and analysis: (1) biophysical environments; (2) socio-economic activities; (3) cultural factors; and 4) institutional scope.

Field work was important, perhaps not so much in terms of detailed data collection but as an irreplaceable means to acquire direct experience on the nature and conditions of natural and cultural resources. For example, it was only through field observations that a proper assesment of living conditions in Indian reservations was made. Also, it was the physical confirmation of land use patterns in Indian reservations, national parks and biological reserves that led to realistic proposals for boundary redefinition.

It is not an exaggeration to state that the perspectives gained through field work strongly influenced all of the planning decisions that were made. Without this experience, many of these decisions would have undoubtedly been inappropriate.

Data Analysis

This stage emphasized the analysis of data on the study region as a means of gaining greater understanding of how various components of the region interacted. For example, an analysis of the region under study was made according to its biophysical processes, characteristics of economic activities, cultural factors, etc.

The maps produced by the project were used to bring out the many spatial and temporal relationships that were previously unorganized in a systematic and comprehensive way. Each map presents a specific feature over the entire study area and consequently can be used on its own.

Map analysis was used with other informational tools, including tabular, matrix and other formats, and help focus attention on issues such as:

- Environmental impacts of major development projects located within or adjacent to the biosphere reserve.

- Assessments of alternative locations for the development of infrastructive facilities.

- Identification of areas which may require special protection based on biophysical characteristics and inferred environmental stresses (critical areas).

- Identification of the spatial dimensions needed for resource management (zoning).

- Identification of data gaps and research needs in relation to specific problems.

Data Synthesis

This stage emphasized the synthesis or "bringing together the separate elements from analysis into the whole." This provided a composite picture of the interrelationship among physical processes, significant biological areas, and current economic activities. The synthesis produced the plan of action necessary to achieve sustainable development. Graphically it is represented by the Biosphere Reserve Zoning Map. It was at this point that the project team was able to define "measures to achieve the objectives" and/or formulate a desirable scenario; in other words, the document entitled, "La Amistad Biosphere Reserve: A Strategy for its Conservation and Development."

The strategy identifies actions required to fill information gaps, identifies legislative and administrative measures, determines the necessary institutional arrangements, and sets out a plan of action for political decision-making and allocation of resources to achieve conservation and sustainable development.

The plan of action also sets out a program of maintenance of essential ecological processes, preservation of genetic diversity, and identification of zones and types of sustainable utilization. The following sections describe the steps which should be followed by the institution(s) coordinating biosphere reserve management. In Costa Rica, this would be the Ministry of Natural Resources, Energy, and Mines.

Implementation

The implementation/coordination phase of the environmental planning process is the time when the recommendations of the strategic plan (Data Synthesis) are carried out. These recommendations may be directed towards the improvement of insititutional capacity and the legislative or policy changes required in order to respond to specific resource problems. They may also be directed towards direct response to a resource problem where the institutional capacity and authority to respond already exist.

Results of the implementation phase are expected to be direct conservation-oriented actions. They may involve institutional arrangements, locating sources of money, legislation, policies, research, reports, or infrastructure development.

Evaluation

The results of the strategic plan of action should be closely followed, and the strategy adjusted in light of improvement, deterioration or absence of change. "Strategies and plans are means and not ends in themselves. But the process by which they are advanced is itself usually of value, as it can inform and educate, develop participation in and support for decision-making, change attitudes, and help to foster a conservation ethic" (IUCN 1980).

Feedback

The environmental planning proccess is not a static, unmodifiable model. It is susceptible to the incorporation of all new information gained during the process itself. Following systems theory principles, the planning process produces modifications through feedback messages.

This can happen at any stage in the planning process. For example, particular results in data analysis could help redefine aspects of the overall problem analysis and determine the need for new data collection.

Once the strategy is defined and implementation begins, social and biophysical factors in unforseen directions may require modifications in the strategy. With the passage of time, the situation will change sufficiently to require the wholesale revamping of the strategy (see Figure 1).

Discussion

Prior to the creation of protected areas in what is now the La Amistad Biosphere Reserve, the adverse environmental conditions and efforts by individuals and community groups helped conserve the outstanding resources of the region. Today, the situation has changed in important ways. While La Amistad has attracted increasing international attention, the pressures on the reserve have also increased significantly. The experience gained in La Amistad confirms the thesis that each biosphere reserve is a unique situation, which requires a great deal of flexibility and imagination in designing and executing management strategies (Batisse 1986).

The Conservation and Development Strategy is a tool that will enable community leaders, government officials, and donor agencies to better understand the relationships between the conservation of natural resources in the region and development. The proposed Plan of Action (Torres and Hurtado 1987) outlines a broad range of activities that promote sustainable development within the reserve. At the same time, the strategy seeks to support the initiatives of the Indian communities which have lived in the area for centuries without disrupting the natural processes of the region.

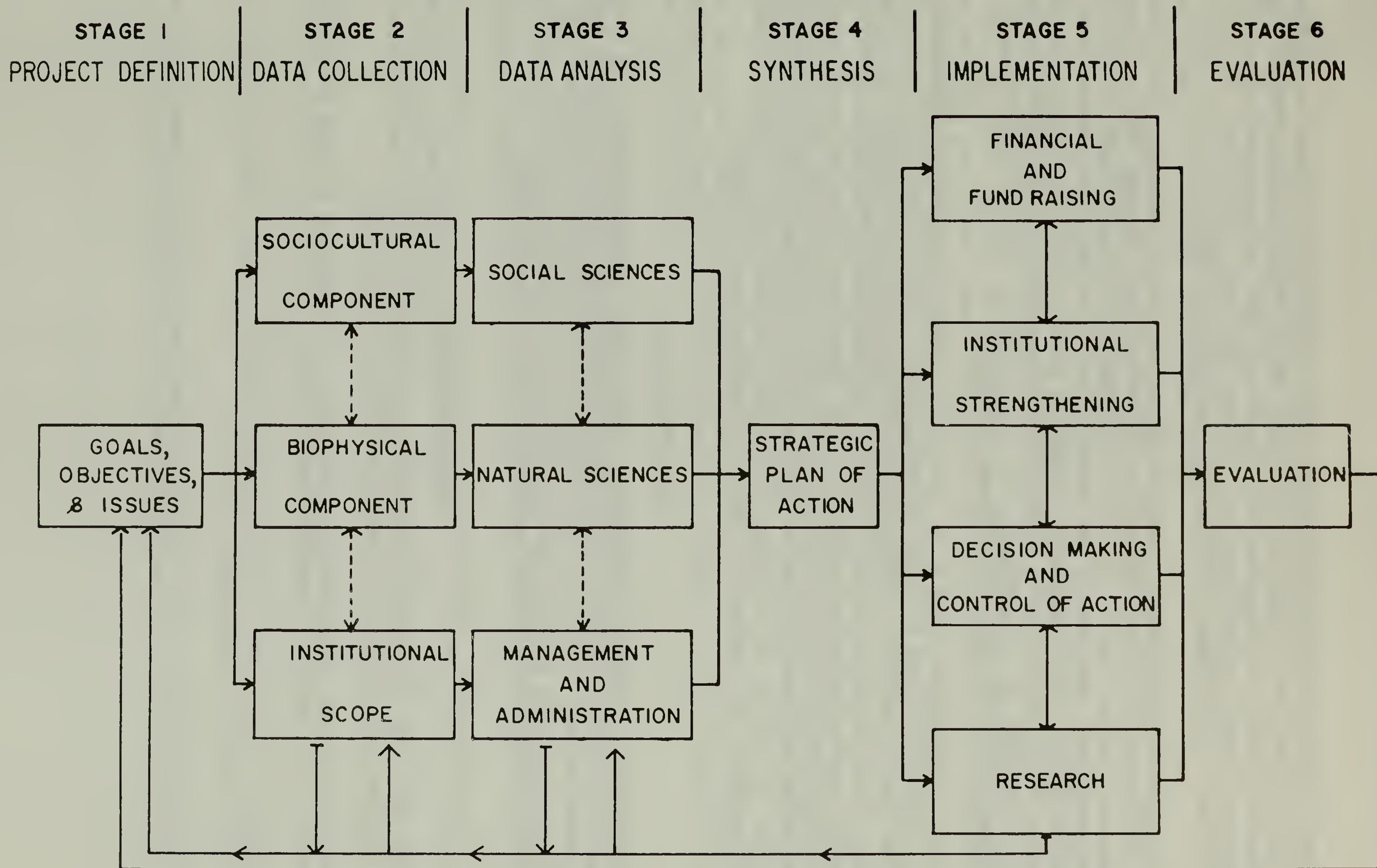
The planning project provided additional momentum for the initiation of integrated management through informational meetings and individual interviews with government personnel, investigators, and community leaders in and around the biosphere reserve. Through these contacts, it was possible to provide details about the project and gather information concerning local priorities and problems. Important contacts with groups promoting the establishment of the Panamanian sector of La Amistad were also renewed and extended.

The planning process has also produced important changes in attitudes. Indian communities that previously had received little information regarding biosphere reserve

FIGURE I

LA AMISTAD BIOSPHERE RESERVE

ENVIRONMENTAL PLANNING PROCESS BY STAGES



activities became interested participants after being visited by team representatives. Gradually, suspicion was transformed to trust, and the traditional stereotype of the shy, introverted "Cholo" was forgotten, as the backwoods savvy and organizational capacity of community leaders became apparent. For the first time, park service personnel and Indian reserve rangers began talking about collaborative actions.

An important step towards biosphere reserve management has been taken. However, the implementation of the Conservation and Development Strategy, and its subsequent evaluation, requires further efforts to consolidate the progress made so far. If the recommendations contained in the strategy lead to strong, mutli-sector policies, if increased national and international funding is made available to support management activities, and if the network of institutions and individuals working towards conservation and development is strengthened, then the union of economic development with environmental and cultural protection may be possible.

The planning process used in the case of La Amistad produced recommendations for action that will be used as guides for management. They also represent objectives that can be used to mark the progress made in conserving and developing the biosphere reserve. With the passage of time, the social, political, and environmental realities in the biosphere reserve may change radically, and the management priorities should be adjusted accordingly. The experience gained during the next few years during the implementation phase should help determine the validity not only of the Conservation and Development Strategy, but also of the environmental planning methods used to develop it, and their usefulness within the framework of the MAB Biosphere Reserve Network.

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A CASE STUDY OF THE MT. KULAL BIOSPHERE RESERVE

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ABSTRACT. The Mt. Kulal Biosphere reserve, which is situated in the arid zone of northern Kenya, is a unique reserve. Its survival depends on striking balance between the resources of the area and the pastoralist population there. Trying to establish this balance has been the task of the UNESCO-Integrated Project in Arid Lands, which was set up at the same time as the establishment of the biosphere reserve. The main aim of the project was to investigate and evaluate all aspects of the ecology, economy, culture, sociology and political situation of the area with a view to contributing designed management plans that would achieve a sustained balance between production and use. After ten years of investigations, the project has now come up with comprehensive management guidelines for the use of the area's resources, which include recommendations on the use of the area's water, grazing resources, woodlands, watei catchments, wildlife, soils, fisheries resources, livestock and human resources and recommendations on the appropriate infrastructure to achieve them.

KEY WORDS: Mt. Kulal, biosphere reserves, deterioration, rehabilitation, conservation, development.

Introduction

The UNESCO-MAB program was created in a world climate of general awakening to all manner of environmental concerns, especially those related to the use of land-based resources. Those charged with the responsibility of managing natural resources were discovering that much of the research on these subjects had little practical value (F. di Castri, 1981). For example, the earth's arid zones attracted considerable scientific attention during the 1950s and 1960s, and a substantial amount of research was done there. Despite the availability of this information, the environmental problems were not solved. There was accelerated deterioration of the arid areas and billions of dollars of development capital, invested in various development projects, were wasted. A better scientific base for the long-term use of natural resources was needed, and concomitantly, new ways of making the efforts of scientists from different disciplines and from different countries available to the resource users from different sectors of society.

MAB was created as a result of these concerns, and charged with the main responsibility for encouraging research on environmental problems with direct and pragmatic application to improved land use and improved resource management. The training of specialists and the promotion of environmental education were recognized as essential adjuncts to the research effort. Both the natural and the social sciences are involved in this effort and the feasibility of integrating the different scientific disciplines is being tested through specified research projects based in the network of biosphere reserves.

The Integrated Project on Arid Lands (IPAL) is one such project located in the Mt. Kulal Biosphere Reserve. It was originally set up as a pilot operation to initiate investigations into the processes of environmental degradation in an arid and semi-arid region inhabited by pastoral nomads and to determine the causes of these processes.

An important focus of IPAL research has been the prediction of the ecological and socioeconomic consequences for the pastoralists of continuing degradation. In the light of its findings, it was intended that IPAL should contribute to the design of management activities directed towards achieving a sustained balance between production and consumption, taking into account the requirements of the growing and increasingly settled population.

It was also hoped, where possible, to demonstrate practical modifications and alternatives to the traditional livestock-based economy which could permit rehabilitation of already degraded lands. Equally important in this regard was the use of project findings in education and training for the dissemination of information on rational management.

Since most of the changes and processes being investigated should be scientifically monitored over the long term, it was recognized that a project would be needed in Marsabit District mainly for this purpose, but also to undertake continued research and training relevant to resource management in the arid zone. The project was also expected to recommend, and assist in the development of, an institutional basis for the required management.

Since its establishment, the project for the last ten years researched several aspects of the experimental management of the region, concentrating upon the "human ecology" of the nomadic pastoralists in dynamic interrelationship with the animals, plants and other resources of the drought-prone, uncertain environment. During the last five years, the investigations in progress were extended and intensified to develop resource management plans for the area, taking into account the increasing human population, the trend towards sedentarization, the degradation of primary productivity and the increasing incidence of soil erosion, all of which are factors resulting in the necessity for constant famine relief measures in the region. This paper presents a summary of the results of the IPAL investigations so far and how these have been incorporated in the development of resource management guidelines for the sustainable conservation of this arid zone ecosystem.

Background

The Mt. Kulal Biosphere Reserve, like many arid areas in the world, is faced with a problem of the deterioration of its resources. In many areas, vegetation cover has been greatly reduced, leading to soil erosion that has resulted in the starvation of both human beings and their livestock. This has necessitated famine relief that has become a constant feature. Several recent socioeconomic factors, contributing to resource degradation, have been identified.

Through the siting and realignment of political and administrative boundaries, the development of forest reserves and national parks, the establishment of commercial ranches, and the influence of missions and other institutions, there has been a restriction of the movement of nomadic people and a reduction in the area they formerly occupied.

Traditional antagonisms between tribes has caused further compression of some tribal groups into a fraction of their former ranges. For example, 25 percent of the present territory of the Rendille pastoralists is not used due to fear of tribal raiding. Another distinctive feature of the problem of deterioration of land in this area is the fact that pastoralists here, unlike those elsewhere, do not have any alternative practices like subsistent agriculture.

Kenya's arid land human population has doubled in the last twenty-five years, and will, if present trends continue, double again the next ten years. The human population pressure is further aggravated by migrations from Kenya's more densely populated areas. Human population growth has also been accompanied by an increase in livestock numbers exerting severe pressure on the grazing resource.

Other trends of far reaching consequence for land use include the excessive demand on woody vegetation for house construction, cattle exclosures and fuel; sedentarization of populations into centers of human and livestock concentrations; and periodic droughts.

The problem of the deterioration of Kenya's arid north, where Mt. Kulal Biosphere Reserve is located, is therefore serious and complex. It concerns the plight of people who are using the only traditional means they have known to cope with a vast problem that has been caused to a great extent by modern influences.

Geographical Location and Area

The study area, which covers approximately 22,000 km^2, including the Biosphere Reserve, is located in the west of Marsabit District in the Eastern Province of Kenya. It lies between 1° 50' and 3° 30N and 36° 30N' and 38° 00'E. To the west lies the eastern shore of Lake Turkana, while to the east is the Nairobi-Moyale road. The location and base map of the study area is shown in Figure 1.

Access from Nairobi is obtained either from the main Nairobi-Moyale road, or from Maralal along the road to Loiyangalani passing through Baragoi and South Horr.

Human Ecology

The human ecology program sought to ascertain the structure, social and economic organization and the dynamics of human populations within the study area and in the national context in order to better understand the actual and potential land use problems in the study area itself and throughout northern Kenya. This program also sought to determine the distribution of the human populations within the area under investigation and, in cooperation with the other components of the study, relate these to essential resources--water, fodder, fuel, building materials and livestock. Equally important in this regard was to ascertain the perceptions of the people concerned with respect to their needs, land use problems, natural environment and aspirations for the future.

The human ecology investigations have so far produced the following results. A description of the demographic structure of the Rendille and Gabra pastoralists and their pastoral households has been accomplished. We now have information on their settlement

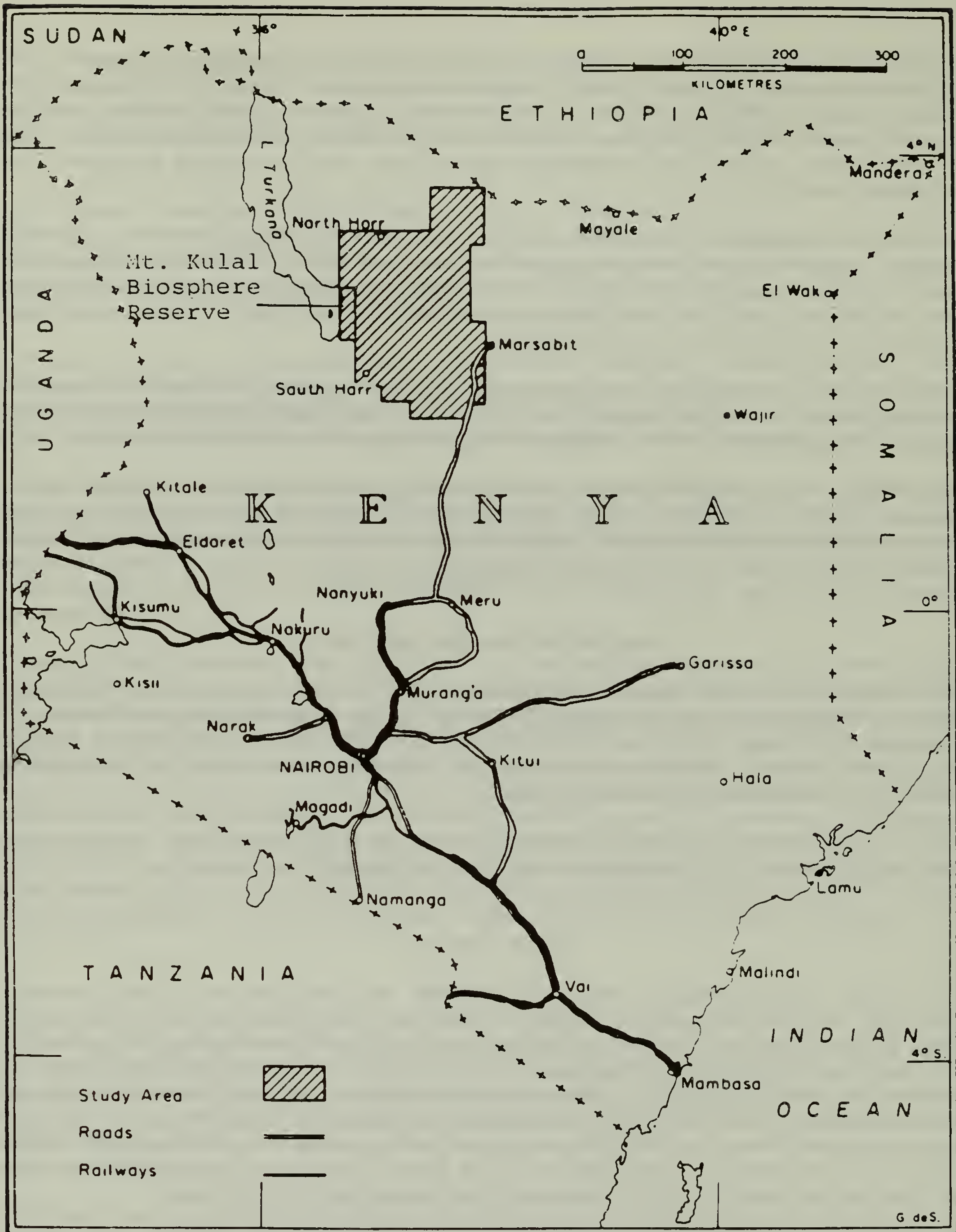

Figure 1. Location of Mt. Kulal Biosphere Reserve and the IPAL study site.

patterns, their movement and that of their livestock, and the indigenous logic behind such movements. Documentation has been made on the effects of sedentarization and other significant departures from the traditional patterns of pastoral practice Two studies by medical doctors have yielded information on the present health status of the population in the light of their changing dietary habits. Social structure and cultural values, insofar as they have a bearing on economic and development issues, have also been described.

Human ecology investigations into the pastoral economy have yielded information on the livestock holdings of pastoral households (i.e., how many camels, cattle, sheep and goats are owned by individual households); the structure of these herds and flocks (i.e., the sex and maturity classes of each animal in the herd); the number of pack camels and donkeys owned by households; herd management practices; patterns in the allocation of household labor with regards to important tasks such as herding, water, milking of livestock and the drawing of water for domestic use; and detailed accounts of the income and expenditure of households, including the number of animals slaughtered for home consumption. Involvement in non-pastoral activities such as schooling, labor migration and agriculture, and assistance programs for pastoralists to diversify the economic basis of their households have also been studied and reported on.

The investigation of the political economy of pastoralists has elevated how decisions are made relative to the movement of their camps and livestock, accepted procedures relating to the digging, maintenance and control of the use of wells, how the local pastoral economies relate to the wider economy and policy, and the implications of national policy for the pastoral economies. Development needs as perceived by the people have also been studied.

The human ecology studies have also included a historical inquiry, since without historical facts as a background for the present ecological setting, there is a risk of making serious mistakes in both research and management because the factors determining the prevailing situation are not understood.

In conjuction with the synthesis of the results of the other IPAL component studies, land management guidelines have been prepared for improving the economic conditions of pastoralists and the long-term conservation of their pastoral habits.

The Physical Environment and Resources

Human land use, notably agriculture and livestock husbandry, is highly dependent on the physical environment- -land forms, soils, hydrology, climate and geomorphology. A comprehensive analysis and understanding of these factors was therefore an absolutely necessary prerequisite for any recommendations on proper land use.

Major Landforms

The major landforms in the IPAL study area have been mapped and described in detail. The bulk of the study area (Fig. 2) is made up of a large central plain which is less than 700 m above sea level (asl). Around this central plain lie a number of volcanic hill masses; the Huri Hills (1,310 m) to the north, Mt. Marsabit (1,836 m) to the east, and Mt.

Kulal (2,295 m) to the west. Mt. Nyiru and Ol'Donyo Mara (over 2,000 m) to the southwest are partly formed from basement material. To the west of Mt. Kulal lies Lake Turkana.

The main drainage lines originate in the hill masses and are mostly in the form of seasonal sand rivers which dry out in the open plains. Most of the land in the study area drains into the Chalbi Desert in the north of the area. There are four major desert plains, the Chalbi, the Koroli, the Hedad and the Kaisut. These together with their soils and vegetation characteristics have formed the basis for the classification of the area into management units.

Soils

The soil is a very valuable natural resource as well as one of the most basic. Man depends on the soil for growing food crops. The amount and quality of the forage for his livestock is related to the soil as well. The processes of soil formation are very slow. It takes thousands of years before soil is formed. Degradation processes can be very fast, especially those caused by man. In a few years a severe physical and chemical degradation can take place and in a few decades a whole soil profile can be lost through erosion processes.

The project has mapped all the soils of the study area, and detailed descriptions of their characteristics and qualities have also been accomplished. The soils are derived either from the Precambrian basement rocks or from more recent volcanic activity. It is estimated that the soils are roughly equally divided between these two parent types. The basaltic lavas from volcanic activity are found around the volcanic hills, while sedimentary deposits are found in the plains. The soils in the north of the Chalbi desert are saline and this area marks the site of a former lake.

On the basis of the soil survey, in combination with climate and vegetation, it has been possible to make a land suitability classification. Based on the characteristics alone, the area has been classified to have the following limitations for grazing:

- 20–25% of the survey area is not suitable.
- 30% of the survey area has strong limitations.
- 20% of the survey area has moderately strong limitations.
- 25% of the survey area has slight or no limitations.

Geomorphology

A detailed map description of the geomorphology of the area has been completed and is contained in three reports. The major task of the work in geomorphology was to characterize erosional processes in their spatial distribution, quantify them and give recommendations for soil conservation. The following major erosional processes can be observed in varying degrees in the study area: fluvial processes, sheet wash, rill erosion, gully erosion, tunnel erosion and deflation by wind. This information has been incorporated in the recommendations for the use of the various areas.

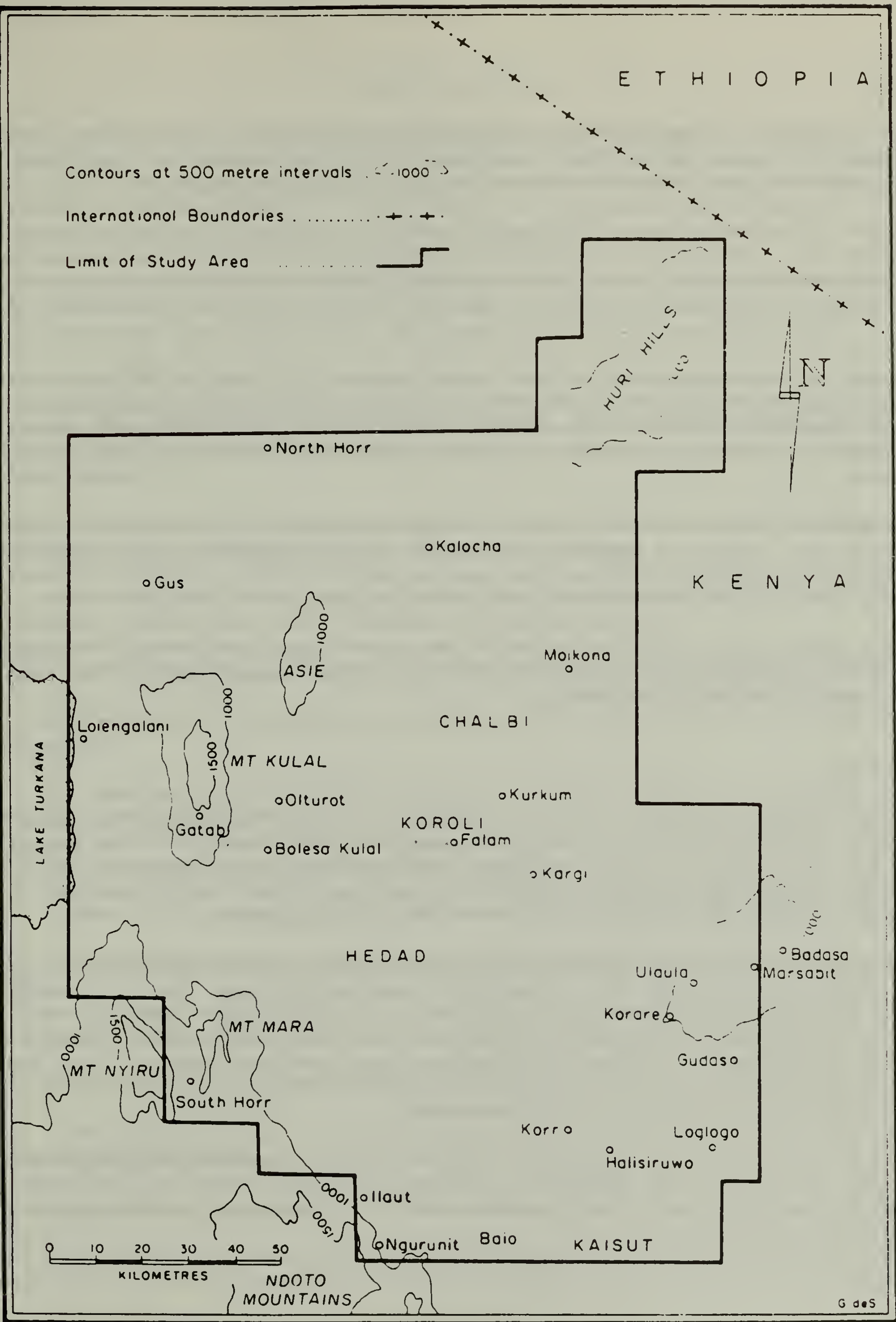

Figure 2. The IPAL study area.

Climate

IPAL climate studies and monitoring have been reported in two technical reports. Generally the climate of the IPAL study area can be characterized as tropical arid and semi-arid, with a few sub-humid areas on the tops of the higher mountains.

Due to the wide range of altitude, there is considerable variation in climate. Following the classification of ecological zones of Pratt et al. (1966) the highland areas are represented by Zone II (sub-humid). As the altitude decreases, the zones change to IV (semi-arid), V (arid) and VI (very arid). The majority of the area falls within Zones V and VI.

Until the establishment of the Arid Lands Project at Mt. Kulal in 1976, the cover of rain gauges was very poor. Apart from the highland masses, the rainfall is low and erratic, ranging from an average of about 700 mm on the mountains to 173 mm in the lowlands. There is now a network of 38 rain gauges in the area and four complete weather stations.

In general the main rainfall occurs in two seasons: March to May, during the southeast monsoon; and October to December, during the northeast monsoon. The rainfall in the lowland areas is highly variable and has been calculated to have a coefficient of variation greater than 50%. The potential evaporation is high, going up to 2,620 mm per year.

The climatic data is still too limited for use in drawing any conclusions with respect to long-term management, but it has been possible to design a grazing pattern that responds to the sporadic nature of the rainfall.

Hydrology

The hydrologic studies on IPAL were designed to furnish information about capacities, variabilities, and the location of known and unknown water resources in the study area, with a view to planning for their best use. Five consultant studies have been carried out and have yielded information on both the ground and surface water resources. These consultant studies have been published in the IPAL technical reports.

Results of these studies reveal that there are sufficient water resources--both ground and surface--in the study area. Resistivity measurements show that it is possible to obtain water almost anywhere in the study area by the use of shallow hand-dug wells. All seasonal rivers have been mapped and their flows are constantly monitored. Possible sites for the development of surface and subsurface dams have been studied. Water balance and stress in both livestock and humans have also been investigated. Recommendations on how stress can be minimized have also been made.

All this information has been used in the development of a water management plan for the area, which takes into account the provision of adequate water for both human and livestock consumption and its equitable distribution over the range for even distribution of livestock grazing pressure.

Vegetation Studies

The Project's first approach to the investigation of desertification in northern Kenya was to initiate a quantitative ecological study of the interactions and relationships between the livestock populations and vegetation. It was envisaged that at least part of the solution to the most obvious problem, that of over-grazing, would depend upon a firm factual basis relating to primary production and animal fodder requirements in the region.

The research program on vegetation has maintained its main objectives; in the short term, to identify and describe the processes contributing to desertification in the region and to determine the nature, rates and causes of the changes taking place in the vegetation. In the long term, the main objective was to provide, for the Government of Kenya, recommendations on the management of the rangelands (within the context of a more comprehensive program of land and social reform), which will ensure the maximum sustainable productivity of the region, based upon the rational and controlled use of the vegetation and appropriate rehabilitation measures. The research has produced the following results:

1. Two vegetation maps of the IPAL study area have been completed. The Range type map gives detailed descriptions of the different range types.

2. Two publications on the annotated checklist of plants in the study area have been produced. This includes a list of Samburu and Rendille names.

3. Forage values of the various plant species have also been determined and described.

4. Estimates of the productivity and nutritive value of the various plant species have been done.

5. An assessment of the range condition of all the range types, based on soils, vegetation and erosion status.

6. Tree planting trials to assess the rate of growth.

7. Assessment of primary production of the herb layer and its relationship to rainfall.

8. An assessment of cover and description of all woody plants and trees in the study area.

9. Determination of woodland dynamics, structure productivity and biomass.

10. Investigation into alternative fencing materials.

11. Determination of the livestock carrying capacity and optimal stocking levels of various vegetation types.

12. Assessment of the wood requirements of the pastoralists.

All these results have been synthesized and incorporated into the plan for controlled grazing and the resource management guidelines that have been developed by the project.

Livestock Studies

Livestock, through the direct impact of their grazing and trampling and indirect effects such as those from the construction of their night enclosures, are the most important component in the pastoral ecosystems of northern Kenya. They are the main source of food, principally milk and meat, for the traditional nomad. Camels and donkeys are also essential for transport.

The main problem with Rendille livestock is that they are unproductive. They suffer from diseases and high levels of mortality. For example, it is estimated that between 20 and 30% of all cattle in Marsabit District died in the drought of 1971 and again in 1981 (FAO 1971; Field 1981). Overstocking of animals leads to localized destruction of the range resource and desert encroachment.

The major objective of IPAL's livestock studies, therefore, is to develop management stategies that will restore environmental stability. This specifically has involved the assessment of the current importance and potential economics of livestock population parameters, and their trends and environmental impact; and the development of livestock grazing and production strategies for controlled range use and long-term sustained yield.

IPAL's livestock studies are concentrating on the four culturally and economically most important species to the people in the area---camels, cattle, sheep and goats. The following results have so far been obtained.

1. A survey of the study area to determine annual and seasonal livestock and wildlife numbers and their fluctuation has been done. This includes estimates of actual stocking rates and distributions in relation to a variety of environmental parameters.

2. An assessment of the nutritional value of important key plants in the diet of livestock and whether they meet the basic requirements at different seasons.

3. Stocking trials to assess the correct stocking levels for the different range types.

4. A determination of the production status of the livestock---milk, calving, mortality, and herd structure.

5. An assessment of the effects of disease on livestock production and determination of the cost-effectiveness of treatment.

6. Evaluation of the present uses of livestock by their owners and determination of their effectiveness in meeting the needs of society.

7. Recommendations on livestock improvement and controlled grazing.

Studies in Pastoral Economics

Many practices of animal husbandry and land use that seem grossly counterproductive may be necessary adaptations to the present economic conditions. These may be inherent in the production system or dictated by developments in other parts of the country, or even in world markets, and therefore outside the pastoralists' control. Without a proper understanding of these economic conditions and a conscious attempt to change them for the better, or adapt to them, any management proposals recommending changes in present behavioral patterns may not find ready acceptance. The economic studies were therefore designed to describe the economic relationships that exist within the Rendille pastoral system and also investigate ways and means of improving the efficiency with which the economic functions of production and distribution of goods and services provided will be carried out. These studies have so far yielded the following results.

An estimate of the annual production of livestock and livestock products available for the satisfaction of human wants like food, shelter and clothing has been made. This includes estimates of the quantities of these commodities necessary for satisfying subsistence needs under present conditions and what surpluses are available for marketing. Quantities of imported maize flour, sugar and tea have also been determined. A study has been made of the marketing channels for livestock and other products. An investigation has been completed on alternative sources of income, such as the sale of gum arabic from *Acacia senegal*, collection of honey, small hides and skins industries, the possibility of marketing abbatoirs to process meat and the making of milk products like cheese. All this information has been incorporated in the resource management guidelines for the area.

Education, Training and Extension

The education and training efforts of IPAL have been both at the professional and the local level. In fulfilment of one of MAB's major objectives of bringing scientists from different backgrounds and countries together, IPAL has organized four orientation seminars which have brought together 68 scientists from some 33 countries. In addition to these seminars, more than 1000 scientists, administrators and other professionals from 56 countries have paid visits to the project.

At the second level, IPAL made available several post-graduate fellowships for the training of local scientists in problems of arid land management. So far, six students have completed their Masters degrees and two are in the process of completing their PhD degrees. All the practical work for these studies has been done on IPAL.

IPAL has, at the technician level, trained 30 field assistants who are working with the project. These field assistants are mostly youth from the area who have left high school and have had no other opportunities of employment.

IPAL has also organized six other seminars for the local people and their councillors, chiefs and area administrators. These seminars deal especially with the problems of land management and environmental degradation in the area.

As a means to investigate the best way to communicate with pastoral nomads, IPAL organized and ran two radio programs on the Voice of Kenya. These were broadcast for one year in Rendille and Boran languages and covered a wide range of environmental subjects relevant to the area.

Resource Management Guidelines

One activity of far-reaching importance is the integration of all IPAL studies into resource management guidelines and plans for the area. These plans, which have been made in consultation with people, are based on appraisals of socioeconomic, cultural and ecological conditions and have tried to balance resource conservation and use in both the short and long term.

For the implementation of any resource management plan to succeed, it must adequately take into consideration the socioeconomic setting and development program of the particular country involved. Recognizing the importance of the range areas of Kenya (which cover more than 80 percent of the total area of the country) and their potential for the production of goods and services, and recognizing also the dangers of erosion and desertification from indiscriminate use, the Government has placed considerable emphasis on the proper development of these lands, based on the following principles:

(a) That the people of the range areas must be allowed the opportunity for full social development in terms of the modern world and in accordance with the principles of human rights;

(b) That range areas should be developed, conserved, and managed in accordance with the ecological principles of proper land use; and

(c) That, insofar as other principles allow, the range areas should be developed to yield maximum benefit to the national economy.

Kenya's Development Plan for the years 1974–1978, in support of agriculture in general and of smallholders and the rural poor in particular, pointed out the need to pay greater attention to the development of the range areas. Even greater emphasis has been placed on the development of range areas in the current National Development Plan (1984–1988). The attention directed to range areas is in line with the broader goals for the national economy. These are clearly specified in the Development Plan and emphasize the importance of continued economic growth, a greater sharing of the benefits of growth by poorer segments of society, full control over the country's economy and broader participation by local organizations in governmental planning.

Since Kenya largely depends on primary production from its land resources, the full potential of the land must be developed by every means. But development must take the form most suited to the prevailing circumstances and the purpose to which an area is best adapted.

In view of the above considerations, it is therefore the policy of the resource management plan developed by IPAL to contribute to the improvement of the well-being of the Rendille people in all ways, but in particular by the development of an improved land-use system that will reverse the trend of land degradation and sustain land protection for the needs of the growing and partially sedentarized pastoral population.

Any developmental and environmental program that seeks the welfare of the local pastoralists must, first of all, strengthen the present pastoral economy. The prime emphasis on livestock sector interventions at this time should be to support the subsistence base of pastoral herding rather than to stress commercial activities. Once the pastoral economy has been placed on a firmer and less vulnerable basis, there is no reason why it cannot produce a surplus of livestock and meat for the wider economy as well as enrich the local community. The pastoral economy can be bolstered by remedying the constraints under which it is at present laboring, and in the process new opportunities will emerge for the pastoralists.

The Rendille of Kargi place their development needs in the following order: (1) water development; (2) improved marketing facilities for livestock; (3) improved medical services; (4) establishment of an adequate veterinary service; (5) improvement of public security; (6) leadership which will get all the people of the tribe working together towards development; and (7) drought assistance.

It is critically important that these priorities, as perceived by the people, be taken into account when phasing development intervention. However, some items of obvious importance are absent from the people's list, primarily because they have no experience of their value. Such are the needs for grazing control, means of storing wealth other than "on the hoof" (i.e., banking facilities), and the registering of tribal rangelands in order to put them on a firm legal basis.

Adding these to the list, we can divide the constraints to which the pastoral economy is at present subjected into three groups, as follows:

1. Constraints on the Use of the Rangelands. Lack of a sufficient number of water sources, lack of grazing control, lack of public security, lack of a sufficiently secure land tenure system.

2. Constraints on Livestock Management and Husbandry. Inadequate marketing facilities, inadequate veterinary services, inadequate banking facilities.

3. Constraints on Human Welfare. Inadequate health services, inadequate measures against drought.

The first group of constraints deal mainly and directly with the economic life of the pastoralists. To generate funds to finance regional welfare schemes, it is first necessary to develop the pastoral economy. The resource management objectives, plans and proposals seek to fulfill this need.

Conclusions

With the synthesis of the results of research into resource management guidelines for the area, the IPAL project has achieved one of the most important goals of the UNESCO-MAB program--finding a better scientific base for the long-term use of the natural resource. These resource management guidelines will form the basis for a regional development project to be implemented by the Government of Kenya. It is hoped that the IPAL scientists will have the opportunity to participate in the initial stages of this implementation so that they can test the outcomes of their own recommendations. A major function of the scientists will be to monitor closely this implementation and make the necessary adjustments before full implementation. Whether these plans will work will depend almost entirely on the support they receive from the people and the Government. The people and the government have pledged this support and we are all anxious to see how it will work on the ground. With all the preparations and effort already put in the project, we believe IPAL will demonstrate the fulfillment of its final objective--through research and training, improved land use systems can be devised to reverse the trend of land degradation and to sustain land production for the needs of the growing (and partially sedentarized) pastoral population of northern Kenya.

Acknowledgements

The author wishes to acknowledge the contributions made to this paper by all IPAL scientists.

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APPENDICES

LIST OF BIOSPHERE RESERVES
(as of March 1988)

Biosphere Reserve	Area (ha)	Date of approval
ALGERIA		
Parc national du Tassili	7,200,000	1986
ARGENTINA		
Reserva de la Biosfera San Guillermo	981,460	1980
Reserva Natural de Vida Silvestre Laguna Blanca	981,620	1982
Parque Costero del Sur	30,000	1984
Reserva Ecologica de Nacunan	11,900	1986
AUSTRALIA		
Croajingolong	101,000	1977
Danggali Conservation Park	253,230	1977
Kosciusko National Park	625,525	1977
Macquarie Island Nature Reserve	12,785	1977
Prince Regent River Nature Reserve	633,825	1977
Southwest National Park	403,240	1977
The Unnamed Conservation Park of South Australia	2,132,600	1977
Uluru (Ayers Rock-Mount Olga) National Park	132,550	1977
Yathong Nature Reserve	107,241	1977
Fitzgerald River National Park	242,727	1978
Hattah-Kulkyne NP & Murray-Kulkyne Park	49,500	1981
Wilson's Promontory National Park	49,500	1981
AUSTRIA		
Gossenkollesee	100	1977
Gurgler Kamm	1,500	1977
Lobau Reserve	1,000	1977
Neusiedler See-Osterreichischer Teil	25,000	1977
BENIN		
Reserva de la biosphere de la Pendjari	880,000	1986
BOLIVIA		
Parque Nacional Pilon-Lajas	100,000	1977
Reserva Nacional de Fauna Ulla Ulla	200,000	1977
Estacion Biologica Beni	135,000	1986

BULGARIA		
Parc national Steneto	2,889	1977
Reserve Alibotouch	1,628	1977
Reserve Bistrichko Branichte	1,177	1977
Reserve Boatine	1,281	1977
Reserve Djendema	1,775	1977
Reserve Doupkata	1,210	1977
Reserve Doupki-Djindjiritza	2,873	1977
Reserve Kamtchia	842	1977
Reserve Koupena	1,084	1977
Reserve Mantaritza	576	1977
Reserve Maritchini ezera	1,510	1977
Reserve Ouzounboudjak	2,575	1977
Reserve Parangalitza	1,509	1977
Reserve Srebarna	600	1977
Reserve Tchervenata stena	812	1977
Reserve Tchouprene	1,440	1977
Reserve Tsaritchina	1,420	1977
BURKINA FASO		
Foret classee de la mare aux hippopotomes	16,300	1986
CAMEROON, UNITED REPUBLIC OF		
Parc national de Waza	170,000	1979
Parc national de la Benoue	180,000	1981
Reserve forestiere et de faune du Dja	500,000	1981
CANADA		
Mont St. Hilaire	5,550	1978
Waterton Lakes National Park	52,597	1979
Long Point Biosphere Reserve	27,000	1986
Riding Mountain Biosphere Reserve	297,591	1986
CENTRAL AFRICAN REPUBLIC		
Basse-Lobaye Forest	18,200	1977
Bamingui-Bangoran Conservation Area	1,622,000	1979
CHILE		
Parque Nacional Fray Jorge	14,074	1977
Parque Nacional Juan Fernandez	9,290	1977
Parque Nacional Torres del Paine	184,414	1978
Parque Nacional Laguna San Rafael	1,742,448	1979
Parque Nacional Lauca	358,312	1981
Reserva de la Biosfera Araucarias	81,000	1983
Reserva de la Biosfera La Campana - Penuelas	17,095	1984

CHINA		
Changbai Mountain Nature Reserve	217,235	1979
Dinghu Nature Reserve	1,200	1979
Wolong Nature Reserve	207,210	1979
Fanjingshan Mountain Biosphere Reserve	41,533	1986
Xilin Gol Natural Steppe Protected Area	1,078,600	1987
Fujian Wuyishan Nature Reserve	56,527	1987
COLOMBIA		
Cinturon Andino Cluster Biosphere Reserve	855,000	1979
El Tuparro Nature Reserve	928,125	1979
Sierra Nevada de Santa Marta (incl. Tayrona NP)	731,250	1979
CONGO		
Parc national d'Odzala	110,000	1977
Reserve de la biosphere de Dimonika	62,000	1988
COSTA RICA		
Reserva de la Biosfera de la Amistad	584,592	1982
Cordillera Volcanica Central	144,363	1988
COTE D'IVOIRE		
Parc national de Tai	330,000	1977
Parc national de la Comoe	1,150,000	1983
CUBA		
Sierra del Rosario	10,000	1984
Cuchillas del Toa	127,500	1987
Peninsula de Guanahacabies	101,500	1987
Baconao	84,600	1987
CZECHOSLOVAKIA		
Krivoklatsko Protected Landscape Area	62,792	1977
Slovensky Kras Protected Landscape Area	36,165	1977
Trebon Basin Protected Landscape Area	70,000	1977
Palava Protected Landscape Area	8,017	1986
DENMARK		
Northeast Greenland National Park	70,000,000	1977
ECUADOR		
Archipielago de Colon (Galapagos)	766,514	1984
EGYPT		
Omayed Experimental Research Area	1,000	1981

FRANCE		
Atoll de Taiaro	2,000	1977
Foret domaniale du Fango	6,410	1977
Reserve nationale de Camargue BR	13,117	1977
Reserve de la biosphere du PN des Cevennes	323,000	1984
GABON		
Reserve naturelle integrale d'Ipassa-Makokou	15,000	1983
GERMAN DEMOCRATIC REPUBLIC		
Middle Elbe Biosphere Reserve	17,500	1979
Vessertal Nature Reserve	1,384	1979
GERMANY, FEDERAL REPUBLIC OF		
Bayerischer Wald National Park	13,100	1981
GHANA		
Bia National Park	7,770	1983
GREECE		
Gorge of Samaria National Park	4,840	1981
Mount Olympus National Park	4,000	1981
GUINEA		
Reserve de la biosphere des Monts Nimba	17,130	1980
Reserve de la biosphere du Massif du Ziama	116,170	1980
HONDURAS		
Rio Platano Biosphere Reserve	500,000	1980
HUNGARY		
Biosphere Reserve of Aggtelek	19,247	1979
Hortobagy National Park	52,000	1979
Kiskunsag Biosphere Reserve	22,095	1979
Lake Ferto Biosphere Reserve	12,542	1979
Pilis Biosphere Reserve	23,000	1980
INDONESIA		
Cibodas Biosphere Reserve (Gunung Gede-Pangrango)	14,000	1977
Komodo Proposed National Park	30,000	1977
Lore Lindu Proposed National Park	231,000	1977
Tanjung Puting Proposed National Park	205,000	1977
Gunung Leuser Proposed National Park	946,400	1981
Siberut Nature Reserve	56,000	1981

IRAN		
Arasbaran Protected Area	52,000	1976
Arjan Protected Area	65,750	1976
Geno Protected Area	49,000	1976
Golestan National Park	125,895	1976
Hara Protected Park	85,686	1976
Kavir National Park	700,000	1976
Lake Oromeeh National Park	462,600	1976
Miankaleh Protected Area	68,800	1976
Touran Protected Area	1,000,000	1976
IRELAND		
North Bull Island	500	1981
Killarney National park	8,308	1981
ITALY		
Collemeluccio-Montedimezzo	478	1977
Foret Domaniale du Circeo	3,260	1977
Miramare Marine Park	60	1979
JAPAN		
Mount Hakusan	48,000	1980
Mount Odaigahara & Mount Omine	36,000	1980
Shiga Highland	13,000	1980
Yakushima Island	19,000	1980
KENYA		
Mount Kenya Biosphere Reserve	71,759	1978
Mount Kulal Biosphere Reserve	700,000	1978
Malindi-Watamu Biosphere Reserve	19,600	1979
Kiunga Marine National Reserve	60,000	1980
KOREA, REPUBLIC OF		
Mount Sorak Biosphere Reserve	37,430	1982
MALI		
Parc national de la Boucle du Baoule	771,000	1982
MAURITIUS		
Macchabee/Bel Ombre nature Reserve	3,594	1977
MEXICO		
Reserva de Mapimi	100,000	1977
Reserva de la Michilia	42,000	1977
Montes Azules	331,200	1979
Reserva de la Biosfera El Cielo	144,530	1986
Reserva de la Biosfera de Sian Ka'an	528,147	1986
Reserva de la Biosfera Sierra de Manantlan	139,577	1988

NETHERLANDS		
Waddensea Area	260,000	1986
NIGERIA		
Omo Strict Nature Reserve	460	1977
NORWAY		
Northeast Svalbard Nature Reserve	1,555,000	1976
PAKISTAN		
Lal Suhanra National park	31,355	1977
PANAMA		
Parque Nacional Fronterizo Darien	597,000	1983
PERU		
Reserva de Huascaran	399,239	1977
Reserva del Manu	1,881,200	1977
Reserva del Noroeste	226,300	1977
PHILIPPINES		
Puerto Galera Biosphere Reserve	23,545	1977
POLAND		
Babia Gora National Park	1,741	1976
Bialowieza National Park	5,316	1976
Lukajno Lake Reserve	710	1976
Slowinski National Park	18,069	1976
PORTUGAL		
Paul do Boquilobo Biosphere Reserve	395	1981
ROMANIA		
Pietrosul Mare Nature Reserve	3,068	1979
Retezat National Park	20,000	1979
Rosca-Letea Reserve	118,145	1979
RWANDA		
Parc national des Volcans	15,065	1983
SENEGAL		
Foret classee de Samba Dia	756	1979
Delta du Saloum	180,000	1980
Parc national du Niokolo-Koba	913,000	1981

SPAIN		
Reserva de Grazalema	32,210	1977
Reserva de Ordesa-Vinamala	51,396	1977
Parque Natural del Montseny	17,372	1978
Reserva de la Biosfera de Donana	77,260	1980
Reserva de la Biosfera de la Mancha Humeda	25,000	1980
Las Sierras de Cazorla y Segura BR	190,000	1983
Reserva de la Biosfera de las Marismas del Odiel	8,728	1983
Reserva de la Biuosfera del Canal y los Tiles	511	1983
Reserva de la Biosfera del Urdaibai	22,500	1984
Reserva de la Biosfera Sierra Nevada	190,000	1986
SRI LANKA		
Hurulu Forest Reserve	512	1977
Sinharaja Forest Reserve	8,864	1978
SUDAN		
Dinder National Park	650,000	1979
Radom National Park	1,250,970	1979
SWEDEN		
Lake Torne Area	96,500	1986
SWITZERLAND		
Parc national Suisse	16,870	1979
TANZANIA, UNITED REPUBLIC OF		
Lake Manyara National Park	32,500	1981
Serengeti-Ngorongoro Biosphere Reserve	2,305,100	1981
THAILAND		
Sakaerat Environmental Research Station	7,200	1976
Hauy Tak Teak Reserve	4,700	1977
Mae Sa-Kog Ma Reserve	14,200	1977
TUNISIA		
Parc national de Djebel Bou-Hedma	11,625	1977
Parc national de Djebel Chambi	6,000	1977
Parc national de l'Ichkeul	10,770	1977
UGANDA		
Queen Elizabeth (Rwenzori) National Park	220,000	1979
UKRAINIAN SOVIET SOCIALIST REPUBLIC/UKRAINE		
Chernomorskiy Zapovednik	87,348	1984
Askaniya-Nova Zapovednik	33,307	1985

UNION OF SOVIET SOCIALIST REPUBLICS		
Chatkal Mountains Biosphere Reserve	71,400	1978
Kavkazskiy Zapovednik	263,477	1978
Oka River Valley Biosphere Reserve	45,845	1978
Repetek Zapovednik	34,600	1978
Sikhote-Alin Zapovednik	340,200	1978
Tsentral 'nochernozem Zapovednik	4,795	1978
Astrakhanskiy Zapovednik	63,400	1984
Kronotskiy Zapovednik	1,099,000	1984
Laplandskiy Zapovednik	278,400	1984
Pechoro-Ilychskiy Zapovednik	721,322	1984
Sayano-Shushenskiy Zapovednik	389,570	1984
Sokhondinskiy Zapovednik	211,000	1984
Voronezhskiy Zapovednik	31,053	1984
Tsentral'nolesnoy Zapovednik	21,348	1985
Lake Baikal Region Biosphere Reserve	559,100	1986
Tzentralnosibirskii Biosphere Reserve	5,000,000	1986
UNITED KINGDOM		
Beinn Eighe National Nature Reserve	4,800	1976
Braunton Burrows National Nature Reserve	596	1976
Caerlaverock National Nature Reserve	5,501	1976
Cairnsmore of Fleet National Nature Reserve	1,922	1976
Dyfi National Nature Reserve	1,589	1976
Isle of Rhum National Nature Reserve	10,560	1976
Loch Druidibeg National Nature Reserve	1,658	1976
Moor House-Upper Teesdale Biosphere Reserve	7,399	1976
North Norfolk Coast Biosphere Reserve	5,497	1976
Silver Flowe-Merrick Kells Biosphere Reserve	3,088	1976
St. Kilda National Nature Reserve	842	1976
Claish Moss national Nature Reserve	480	1977
Taynish National Nature Reserve	326	1977
UNITED STATES OF AMERICA		
Aleutian Islands National Wildlife Refuge	1,100,943	1976
Big Bend National Park	283,247	1976
Cascade Head Exp. Forest & Scenic Research Area	7,051	1976
Central Plains Experimental Range (CPER)	6,210	1976
Channel Islands Biosphere Reserve	479,652	1976
Coram Experimental Forest (incl. Coram NA)	3,019	1976
Coweeta Hydrologic Laboratory	2,185	1976
Denali National Park and Biosphere Reserve	2,441,295	1976
Desert Experimental Range	22,513	1976
Everglades National Park (incl. Ft. Jefferson NM)	585,867	1976
Fraser Experimental Forest	9,328	1976
Glacier National Park	410,202	1976

Great Smoky Mountains National Park	209,000	1976
H. J. Andrews Experimental Forest	6,100	1976
Hubbard Brook Experimental Forest	3,076	1976
Jornada Experimental Range	78,297	1976
Luquillo Experimental Forest (Caribbean NF)	11,340	1976
Noatak National Arctic Range	3,035,200	1976
Olympic National Park	363,379	1976
Organ Pipe Cactus National Monument	133,278	1976
Rocky Mountain National Park	106,710	1976
San Dimas Experimental Forest	6,947	1976
San Joaquin Experimental Range	1,832	1976
Sequoia-Kings Canyon National Parks	343,000	1976
Stanislaus-Tuolumne Experimental Forest	607	1976
Three Sisters Wilderness	80,900	1976
Virgin Islands National Park & Biosphere Reserve	6,127	1976
Yellowstone National Park	898,349	1976
Beaver Creek Experimental Watershed	111,300	1978
Konza Prairie Research Natural Area	3,487	1979
Niwot Ridge Biosphere Reserve	1,200	1979
The University of Michigan Biological Station	4,048	1979
The Virginia Coast Reserve	13,511	1979
Hawaii Islands Biosphere Reserve	99,545	1980
Isle Royale National Park	215,740	1980
Big Thicket National Preserve	34,217	1981
Guanica Commonwealth Forest Reserve	4,006	1981
California Coast Ranges Biosphere Reserve	62,098	1983
Central Gulf Coastal Plain Biosphere Reserve	72,964	1983
South Atlantic Coastal Plain Biosphere Reserve	444,335	1983
Mojave and Colorado Deserts Biosphere Reserve	1,297,264	1984
Carolinian-South Atlantic Biosphere Reserve	125,545	1986
Glacier Bay-Admiralty Island Biosphere Reserve	1,515,015	1986
URUGUAY		
Banados del Este	200,000	1976
YUGOSLAVIA		
Reserve Ecologique du Bassin de la Riviere Tara	200,000	1976
The Velebit Mountain	150,000	1977
ZAIRE		
Reserve Floristique de Yangambi	250,000	1976
Forest Reserve of Luki	33,000	1979
Vallee de la Lufira	14,700	1982

A total of 269 reserves in 70 countries, covering nearly 1,430,000 km^2.

From the IUCN Conservation Monitoring Centre, March 1988.

Appendix B

WORLD WILDERNESS CONGRESS RESOLUTION ON BIOSPHERE RESERVES

(Editor's Note: At its final plenary session, the Fourth World Wilderness Congress passed a series of resolutions. The following deals specifically with promoting the establishment and functional development of the International Network of Biosphere Reserves.)

Biosphere reserves provide a flexible framework for institutional cooperation to develop a bioregional perspective on interrelated environmental, land use, and socio-economic problems. The international network, and each biosphere reserve, symbolize the common purpose of fostering cooperation at many levels to develop the means of integrating conservation and development, and are in harmony with emerging directions in global conservation.

The Fourth World Wilderness Congress <u>urges</u>:

1. All concerned entities:

   a. To implement the Action Plan for Biosphere Reserves by the end of the planning cycle in 1989.

   b. To increase technical and financial assistance for the establishment of biosphere reserves, especially to stengthen their participation in international scientific research and monitoring programs.

   c. To promote awareness of the biosphere reserve concept and its applications among decision makers and the public through meetings, publications, and use of the media.

2. Governments:

   a. To participate actively in the Man in the Biosphere (MAB) Program and in the implementation of the Action Plan for Biosphere Reserves under the direction of a strong national MAB Committee, which would involve the scientific, development, and conservation sectors in planning and implementing a national program.

   b. To integrate representative wildlands and protected natural areas (core areas) in biosphere reserves with significant cultural landscapes which demonstrate sustainable uses of particular ecosystems, in accordance with the World Conservation Strategy. Special attention should be given to applying the biosphere reserve concept in coastal and marine areas.

3. Governments and biosphere reserve administrators to directly involve local communities in conceptualizing, planning, and implementing biosphere reserve programs, with particular emphasis on local conservation and development issues.

4. MAB National Committees in cooperation with governmental and non-governmental organizations:

a. To identify and support the development of selected biosphere reserves as models for demonstrating the usefulness of the biosphere reserve concept in developing information and appropriate methodologies for addressing interrelated environmental, land use, and socioeconomic problems at the local, regional, and global levels.

b. To encourage the use of biosphere reserves as the focus for developing the theory and application of conservation science, environmental ethics, landscape ecology, and related disciplines.

5. Educational institutions to include the biosphere reserve concept--in both its operational and philosophical dimensions--in the curricula of natural resource training institutions, and to encourage the use of biosphere reserves as sites for the training of planners, scientists, teachers, and future reserve managers.

6. International development agencies and development banks to encourage ecologically sustainable and culturally appropriate rural development projects within buffer zones and transition areas of existing or potential biosphere reserves, to demonstrate the socioeconomic benefits of the biosphere reserve concept as a means to maintain biological diversity.