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BUILDING SCIENCE PROGRAMS TO SUPPORT THE MULTIPLE ROLES OF BIOSPHERE RESERVES

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ABSTRACT

Biosphere reserves conserve representative examples of the world's ecosystems; contribute to maintaining their genetic diversity; and serve as global benchmarks of environmental quality, as centers for developing the knowledge and skills needed for integrated development of particular biogeographic regions, and as focal points for education and training to improve the capabilities of specialists and local people. A large network of protected sites is being established, yet immense challenges remain in developing scientific capabilities which maximize its contribution toward effective policies and programs at the local, regional, and global level for sustainable conservation of natural and managed ecosystems. Approaches for phased development of science programs to carry out the multiple roles of biosphere reserves are discussed, with special emphasis on inventory and ecological measurement in core zones. Attention is given to the urgent need to develop the special capabilities of biosphere reserves in fostering cooperation among nations, between natural and social scientists, and between the scientific community and sectors responsible for making and implementing decisions on the protection, management, and use of ecosystems. The particular constraints associated with applying the biosphere reserve designation to other types of protected areas with more narrowly focused objactives are recognized and possible ways to mitigate problems are suggested.

1. INTRODUCTION

The 1974 report of the Task Force on Criteria and Guidelines for the Choice

and Establishment of Biosphere Reserves stated that "a research programme should be an objective of any biosphere reserve and will provide a means of distinguising the biosphere reserve from the numerous existing programmes aimed exclusively at nature conservation. It is recognized, however, that the first priority should be to identify and protect significant areas. The capability for research programmes may have to be developed over a period of time as personnel and funds become available" (UNESCO, 1974).

During the past nine years, MAB has made significant strides in achieving the Task Force's first priority. To date, 226 protected area units have received the biosphere reserve designation and 62 countries are now counted as participants in the rapidly growing network. Although much remains to be done to achieve adequate representation of the world's ecosystems, the network is secure, if not yet mature. Our success in building the network now provides the opportunity and, in fact, the obligation to put it to use in developing the scientific understanding and practical skills required to manage and sustain the world's ecosystems and the genetic material they contain for improving the quality of life of our fellow human beings. The ultimate success of the biosphere reserve project will depend on how effectively it contributes to solving interrelated ecological and human problems at the local, regional, and global levels. It will equally depend on how well it is able to foster cooperation and communication between scientists, planners, government decisionmakers, and local populations; between natural and social scientists; among institutions; and among nations. Indeed, it is MAB's special capability to bring people together to solve problems wherein lies its greatest potential to promote the advancement of human civilization. As securely protected sites for research, demonstration, and training, biosphere reserves will play an increasingly important role in conservation and integrated development. It is obvious that the contribution of each reserve and the network as a whole

will depend on the impact of its science program, and that building scientific capabilities must receive urgent attention.

2. THE NEED FOR GUIDANCE

In order for biosphere reserves to fulfill their multiple roles, they must contain areas having suitable boundaries and management objectives to enable each of these roles to be implemented. The existing international network is largely an aggregation of preexisting protected areas, established under their own legal authorities which specify their purpose, determine their boundaries, and place limits on their management objectives and programs. By relying on these authorities to provide protection and management direction, it has been possible to obtain endorsements from many administrators in a short time. However, what has been helpful in building the network creates particular challenges in developing its functions.

Because legal constraints and obligations are lacking, many administrators have considered biosphere reserve designation more as an honor than as an obligation. The mission of biosphere reserves in providing the scientific basis for integrated development, and the implications of this mission in developing science programs for individual sites, are not well appreciated. However, there is no doubt that biosphere reserve designation has played a role in promoting and upgrading science programs. For example, in the United States, the 18 units of the 334-unit National Park System which have been designated biosphere reserves receive nearly 40% of the administering agency's science budget, and employ about % of its field scientists. There is some evidence that biosphere reserve status may be redirecting science programs toward more interdisciplinary, system-oriented studies, and more domestic and international cooperation under the aegis of MAB. However, the level of such activities involving the U.S. reserves is disappointingly low (Gregg and Goigel,

in press). Nevertheless, it is encouraging that administrators increasingly are requesting information on biosphere reserves, and express the desire to understand and act upon their responsibilities to develop biosphere reserve functions. The need for more guidance seems clear, to provide administrators with the information and perspective required to identify realistic ways to contribute to, and benefit from, the biosphere reserve project.

The development of guidance is particularly challenging because of the extreme variation in reserve characteristics, such as boundary configuration, size, ecosystem structure and condition, purpose and management objectives, the history of scientific study, scientific and managerial capabilities and facilities, and the socioeconomic conditions and human value systems of the local area. Together, these characteristics determine a reserve's ability to develop an effective science program, the objectives of the program, and the type of contributions it makes within the network. Assistance from MAB must take these variations into account in providing a framework for solving problems locally and, through MAB linkages, in the biogeographic region and at the international level.

3. SOME BASIC REQUIREMENTS

Basic requirements for developing science programs should be limited to projects and activities which should be undertaken in all biosphere reserve sites, preferably in accordance with standards developed by MAB. These undertakings should be implemented regardless of the reserve's characteristics as soon as possible after designation, if they have not already been accomplished. Collectively, they should provide the information and infrastructure for basic and applied research on representative ecosystems and the genetic material they contain. They should be within the financial means and technical capabilities of domestic agencies and institutions to

obtain free or at an acceptable cost from other sources. Finally, they should be short-term and normally completed within about three years of designation.

Figure 1 lists some candidates for basic requirements. The bibliography, history of scientific study, species lists, basic resource maps, and management plan should be made available through the MAB National Committee or its designated agent. These references, as updated from time to time, supplement information available in UNESCO's Directory of Biosphere Reserves and the list of current research in the MAB Information System, both of which should be updated regularly. Together, they provide the basic information needed to develop science programs, provide orientation and training for specialists working in the reserve, and encourage regional and international communication and collaboration.

4. BASELINE ECOLOGICAL MEASUREMENTS IN CORE ZONES

Many of the world's foremost sites for obtaining baseline measurements on natural ecosystems are included in the core zones of biosphere reserves. Their secure protection, remote locations, and freedom from the influence of urban and industrial uses make these areas ideal as global benchmarks of environmental quality, ecosystem health, and the status of genetic resources. Their importance continues to grow as places for studying cycles and trends in natural ecosystems, for distinguishing natural from human-caused changes, and for providing an early warning of changes affecting the stability of ecosystems and their habitabiluty for people. Their growing data banks are primary contributors to our understanding of the structure and functions of the world's ecosystems, and to our ability to forecast future conditions and develop effective policies and programs for maintaining, restoring, and enhancing the range of benefits these ecosystems provide. In these areas, the biosphere

FIGURE 1. RECOMMENDED BASIC REQUIREMENTS FOR DEVELOPING SCIENCE PROGRAMS IN BIOSPHERE RESERVES

Comprehensive Annotated Bibliography

The bibliography should be in standard format and include locations where unpublished and published literature of local or regional distribution may be obtained.

History of Scientific Activities

This basic reference for the specialist includes descriptions and tabular presentations on the scope, methodology, and importance of research and monitoring activities (by component of the environment); the history of resource and development plans; the types and locations of collections; cultural factors, policies, available logistical support and facilities, and other factors relevant to use of the site for research. Such a reference series has been initiated in the U.S, and eight volumes are completed or in progress. The volumes are extremely useful in science program development, training, and facilitating cooperation.

Library

A library located within the reserve or in a designated nearby location should be established and maintained as a repository for published and unpublished material, including photography, on the reserve and its vicinity.

Field Station

A basic field station, within easy access of the reserve, is probably the single most important factor in encouraging its use by scientists. The facility should contain space for lodging, meetings, and processing field samples, as well as laboratory and field equipment as required.

Species Lists and Collections

These are usually inadequate for most reserves. Following designation, species lists should be verified and updated to the extent possible, and the content and adequacy of collections in regional and remote repositories evaluated and a collections program developed.

Atlas of Basic Resource Maps

The compendium, covering the reserve and its vicinity, should include at the minimum a geopolitical base map, and maps of land use and land cover, and topography. Maps of surficial geology as well as soils and sediments should be included, if possible. These maps are essential for use in developing infrastructure as well as monitoring, research, and resource management programs. The rapid development of remote sensing technologies has significantly reduced the cost and improved the resolution of resource mapping in recent years to the point where such basic information can often be generated quickly even in the most remote areas.

A Plan for the Biosphere Reserve

A plan establishing management objectives and proposed projects should be prepared either de novo or as a supplement or revision of an existing management plan. The plan should identify a suitable mechanism for encouraging cooperation, identifying problems, and establishing priorities for reserve activities.

Permanent Plots for Long-term Ecological Measurement in Core Zones

Plots for monitoring representative ecosystems should be selected, monumented, photographed, and mapped, and a monitoring program included in the reserve plan as soon as possible following designation.

reserve network inherits the legacy of the evolving science of ecology, as it links together many of the places most important in the development of its theory and practice. The special challenge in the core zones is to develop a truly integrated network where coordinated measurements help provide the scientific basis for sustainable conservation of protected areas, biogeographic regions, and the biosphere as a whole.

To date, MAB has provided only limited guidance on ecological measurements in biosphere reserves. An international MAB workshop, held in the United States in 1978, developed a plan which identified a range of biogeochemical and anthropological parameters for consideration in implementing a phased program (United States National Committee for Man and the Biosphere, 1979). The plan included a core group of parameters for measurement in all biosphere reserves, as well as additional measurements to be considered in developing more detailed and better integrated programs to support modelling, forecasting, and impact assessment activities.

A somewhat more comprehensive statement on requirements for site description and measurement was prepared by The Institute of Ecology (U.S.) for use in developing a long-term ecological research program, sponsored by the U.S. National Science Foundation, in which four biosphere reserves are presently participating (The Institute of Ecology, 1979). Although its capital cost, instrumentation, and technical requirements would preclude full implementation of such a program now in many parts of the world, the statement offers a suitable framework for ecological measurement in most developed countries.

In one area, the monitoring of pollutants, careful planning has produced design criteria, sampling methodologies, quality control requirements, and data management procedures for launching a major program in biosphere reserves. The ecosystem-oriented approach is based on a model of pollutant movement through

the ecosystem, and involves monitoring pollutant levels in air, on deposition surfaces, and in water, soil, litter, and vegetation (Wiersma and Brown, 1980). A project based on this work is being undertaken in forest and grassland biosphere reserves in the United States and the Soviet Union in conjunction with the terrestrial monitoring component of UNEP's Global Environmental Monitoring System . The project is a significant first step in implementing the International Coordinating Council's recommendation of five years ago (UNESCO, 1978) to begin coordinated use of biosphere reserves for environmental monitoring in cooperation with the United Nations Environment Programme and the monitoring programs of the World Health Organization and the World Meteorological Organization. MAB should actively solicit increased funding and technical support from participating developed countries and concerned nongovernmental organizations for expanding this project to include additional biosphere reserves, and for developing additional ecological measurement projects, with particular emphasis on tropical forests, aridlands, island ecosystems, and wetlands.

5. LINKAGES AND INSTITUTIONS FOR APPLIED RESEARCH AND NEW PERSPECTIVES

In recent years, the documentation of significant regional impacts from increasing resource exploitation, rapid land use changes, and pollution has caused unprecedented redirection of interest toward large-scale problems, which have served as a catalyst for improved communication and support for integrated research programs, especially in the developed countries. Managers of biosphere reserves and other protected areas increasingly find these impacts threatening their ability to achieve the protected area's purpose (on which their job performance is evaluated). Their realization that these problems can only be addressed on the basis of convincing scientific evidence and coordinated regional or international action has provided a rallying point for cooperation. Because of the growing amount of funding and technical resources being allocated to these problems, managers are becoming ever more aware that their ability to

achieve local management objectives may depend on their participation in larger efforts. This situation provides opportunities never before available for building linkages and better institutions. Biosphere reserves must provide focal points for these activities.

In the United States, MAB is selecting biosphere reserves so as to develop both a symbolic focus and a practical mechanism to foster cooperation among the institutions of a particular biogeographic region. This is accomplished by linking together land management units under different administrators to form a multiple-site reserve which bears the name of the biogeographic region. The reserve is built opportunistically to conserve the full range of representative ecosystems and offer a similar range of opportunities to support integrated development. The very name of the reserve should thus come to symbolize regional cooperation as successful efforts are undertaken to fulfill its various functions (Gregg, 1983).

The adaptability of a similar approach in a developing region is now being considered in the Lesser Antilles, under the aegis of the Caribbean Conservation Association, which is coordinating studies to identify appropriate sites and priority problems of regional concern with which a coordinated multi-island biosphere reserve should deal (Caribbean Conservation Association, 1983; Gregg, in press). This undertaking provides an exceptional opportunity to develop the full dimensions of the biosphere reserve concept to support sustainable development of a culturally and ecologically diverse region with well established linkages with developed countries. It also could serve as a model for islands, which face challenging ecological and socioeconomic problems, and which are seriously underrepresented in the network.

Biosphere reserves can also provide the catalyst for developing institutions to foster communication among government agencies, academic institutions, and

local people, to develop acceptable solutions for conservation and development problems. In the United States, the prototype for such institutions was established in 1976 in conjunction with biosphere reserves in the Southern Appalachian Mountains, and served as a blueprint for establishing a similar institution last year for the Virgin Islands Biosphere Reserve and its vicinity. These institutions are partnerships between government agencies and scientific institutions, and rely primarily on the planning processes of the land managing agencies for involving local people. In developing countries, direct involvement of local people in cooperative associations, such as those developed in conjunction with Mexico's biosphere reserves (Halffter 1981), can do much to improve communication and alleviate sources of conflict, as well as develop local involvement and support for the reserve. Regardless of the particular situation, possibilities for establishing cooperative institutions should be pursued as an important option for strengthening the role of biosphere reserves in regional integrated development, as well as for improving the effectiveness of National MAB Committees in influencing the development of natural resource policies and programs.

Finally, more linkages among biosphere reserves in different parts of the world are urgently needed to develop the theories, methodologies, models, and data management systems required to address the countless problems of common interest, particularly those requiring the interfacing of physical, biological, and anthropological sciences. Where common interests exist, MAB should encourage and recognize the pairing of biosphere reserves to provide an incentive for continuing collaboration, with special emphasis on establishing linkages between the most ecologically similar reserves. Working in association with participating governments and nongovernmental organizations, MAB should encourage the establishment of funding sources specifically to cover the travel expenses

of field scientists and managers involved in collaborative projects. I am aware of many specialists in biosphere reserves who are interested in pursuing such projects for whom the difficulty in obtaining funds, particularly for recurring travel associated with long-term undertakings, is a serious constraint. Even a modest increase in the availability of funding from domestic and international sources would reap significant benefits in terms of the number of projects which could be undertaken.

6. PROBLEM AREAS FOR BIOSPHERE RESERVE RESEARCH: THE CHALLENGE AHEAD

Each biosphere reserve necessarily must develop a research program uniquely suited to the objectives of its administrators, and to the capabilities, cultural traditions, value systems, and problems of the region. However, there are many areas where large gaps in information provide serious impediments to solving regional or global problems, and where coordinated research in biosphere reserves could make a major contribution.

Figure 2 lists some particularly important research areas, but is far from exhaustive. Nevertheless, most biosphere reserves should be able to make contributions in many of these areas. In developed countries, technological capabilities can be put to use to clarify basic ecological relationships and improve our ability to assess and forecast the consequences of human activities. In the developing countries, existing knowledge can be put to use to develop and demonstrate prototypes for successfully integrating conservation and development, with the active participation of local people and, when possible, the financial support of economic development agencies.

Regardless of the nature of the problems being addressed, it is important that biosphere reserves become widely identified with successful cooperative undertakings to solve practical problems affecting the quality of human life. An

FIGURE 2. SOME PRIORITY AREAS OF RESEARCH IN BIOSPHERE RESERVES

Conservation of Biological Diversity

Life history and population genetics of animal and plant taxa, with emphasis on comparative studies (*)

Requirements for maintaining or restoring populations of rare, endemic, and endangered species, and species of economic or cultural significance

Effects of progressive isolation of protected areas on their effectiveness in conserving biological diversity and the development of management responses

Impacts of exotic species on biological diversity, productivity, and ecosystem stability; and the development of management responses (*)

Ecosystem Processes

Basic research on the cycling of natural elements and compounds in terrestrial and aquatic ecosystems, and between ecosystems by air and water, and on the sensitivity of natural cycles to pollutants (*)

Effects of acidic deposition on biological productivity and diversity, including maintenance and restoration of poorly buffered areas (*)

Effects of harvesting, grazing, and forest practices on nutrient cycles, biological diversity, and productivity, including the long-term impacts of soil erosion (*)

Effects of traditional land use practices on nutrient cycles, productivity, and biological diversity

Identification of symbiotic relationships and other stabilizing factors in natural ecosystems, and applications in managed ecosystems (*)

Interactive effects of natural and anthropogenic stresses on forest ecosystems from physical disturbances, pests, pathogens, acid precipitation, and pollution, including the role of forests as pollution sinks and the effects of pollutant assimilation on forest productivity (*)

Effects of global increases in carbon dioxide, including forecasting of impacts on global habitability (*)

Other Areas of Emphasis

Integrated systems for processing and recovery of wastes (*)

Restoration and development of sustainable production systems for degraded areas, with emphasis on tropical forests and marginal lands

Assessment of economic development projects

Factors affecting the acceptance of new land management technologies by indigenous cultures

(*) Areas identified by The Institute of Ecology (U.S.) in a 1981 assessment of research needed for informed decisions for sustainable conservation of natural and managed ecosystems

ideal science program for biosphere reserves thus should give us models for productive harmony between people and their environment. It should give us the scientific basis for decisions to help address the underlying causes of the instabilities of the present age. It should make MAB's goal of encouraging cooperation a dynamic reality, in which the biosphere reserves hold center stage. Finally, it should give the biosphere reserves their own special identity as places for building a new and more mature ethic of conservation.

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