

INTERNATIONAL CONFERENCE-EXHIBIT

ECOLOGY IN PRACTICE

Establishing a scientific basis for land management

Paris, 22-29 September 1981

THE BIOSPHERE RESERVE PROJECT: THE UNITED STATES EXPERIENCE

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ABSTRACT

The Biosphere Reserve Project is the largest and best known of the 12 MAB Projects presently active in the United States. The nation's Biosphere Reserve System counts 36 units, representing 16 biogeographic provinces and 5 coastal regions. The Project's administrative structure and the selection procedures for U.S. Biosphere Reserves are discussed. The status of monitoring, research, demonstration, training, and public communication is evaluated, and opportunities for improving the impact of the Project in addressing regionally and globally significant ecosystem management problems are explored. The need for integration of ecosystem research and related activities within biotic regions and the development of bilateral pilot projects is emphasized.

KEYWORDS

Biosphere Reserve, Man and the Biosphere Programme (MAB), United States ecosystem research, environmental education.

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Sustained productivity is not a static concept, but requires continual adjustment of land management methods to reflect changes in social, economic, and ecological conditions, as well as the state of scientific knowledge and technological capability. In spite of the United States' relatively low population (221 million in January 1980), the pervasive effects of this population's activities is rapidly creating a nation of the ubiquitous managed landscape, in which maintaining the socioeconomic and natural values of lands and waters increasingly is accomplished through energy-intensive and high-technology operations. In the immediate future scarce energy and mineral resources, as well as other commodities, will increase the cost of many of these operations, and successful efforts to sustain productivity may well depend on unprecedented innovation which enables us to achieve land management goals with less consumption of these resources. Many of these innovations will involve taking better advantage of the characteristics of natural ecosystems and species in ways which reduce the need for such costly supplements and which are acceptable to the people who use them.

The biosphere reserves can and should play a significant role in protecting the planet's biological diversity, and developing the methodologies, understanding, and capability needed for conserving biological diversity as well as maintaining and, where possible, enhancing the productivity of lands and waters to improve the human condition. As the only conservation, research, demonstration, and training sites designated by the world community for this integrated purpose,

the biosphere reserves have a unique mission, which must be carried out on several levels. First, the reserves must provide scientific and educational programs which provide information and technology to serve the immediate, short-term, and long-term needs of management in the reserve itself. Specifically, they must facilitate the development of cost-effective strategies for conserving physical, genetic, and habitat resources, and for enabling timely responses to internal and external threats. Second, the reserves must provide information to enable balanced decisions on significant resources allocation and management problems in a particular biotic region, and thereby contribute to its ecological, social and economic well being. Finally, they must contribute to broad-scale efforts to provide new perspectives on problems common to two or more biotic regions and to characterize natural and human-caused changes in the biosphere itself. In the United States, the biosphere reserves system is making significant contributions on the first two levels. However, there have been only limited and tentative efforts to achieve the degree of cooperation among scientific disciplines, resource managers, and institutions required for a successful extraregional or global venture. The personal and institutional barriers to executing such projects can be formidable; yet it is such activities which give MAB its special identity. Our capability to plan and implement them will ultimately determine the success of the biosphere reserve project and the MAB Programme as a whole as a major force in promoting harmonious coexistence between human beings and the biosphere which supports them.

The following assesses the development of the Biosphere Reserves Project in the United States, with particular emphasis on the problems we have encountered in selecting reserves and developing ecosystem research, monitoring, training, and public communication programs in these areas. The assessment is based on available historical documentation on MAB Project 8, scientific literature involving the biosphere reserves, and a recent survey of biosphere reserve personnel to determine

the status of activities and perceptions of these personnel on the strengths and weaknesses of data bases, facilities, and programs.

A BRIEF HISTORY OF PROJECT 8 IN THE UNITED STATES

Following the UNESCO-sponsored "Biosphere Conference" of September 1968 at which the MAB Program was conceptually launched, and the UNESCO General Conference of November 1980 at which it was programmatically established, United States scientists were continually involved in the planning and development of MAB in general, and MAB Project 8 in particular. After MAB's newly established International Coordinating Council recommended the establishment of the Biosphere Reserves Network as one of MAB's project areas, these scientists helped generate significant support in the United States, both within the scientific community and in government, particularly in the Departments of the Interior, Agriculture, and State. As a result, the United States was able to endorse enthusiastically Recommendations 107-120 of the United Nations Conference on the Human Environment, held in Stockholm in June 1972. These recommendations underscored the conference's support for an international program to establish a "world-wide network of protected areas to preserve representative examples of the world's ecosystems."

Following the Stockholm Conference, the United States participated in important international efforts in 1973 and 1974 which provided the framework for selecting, designating, and managing biosphere reserves (UNESCO 1973, IUCN 1974, Udvardy 1975). However, the impact of these efforts was cast in doubt by the failure of United Nations organizations to fund a 1974 proposal to carry out a six-year program to develop the international network. Threatened with the prospect that the momentum generated by the Stockholm Conference might well abate due to lack of funding, project proponents realized that its survival might well depend on the ability of the developed countries to take the lead in providing the initial financial and moral support needed to get the project underway. The matter was

fortunately scheduled as an agenda item at the Moscow summit conference between Presidents Brezhnev and Nixon in July, 1974. In the official communique, both nations agreed to designate biosphere reserves and utilize them for conducting scientific investigations leading to more effective protection of the global environment. In the United States, this Environmental Agreement immediately provided a catalyst for translating general support for MAB Project 8 into actual establishment of biosphere reserve sites.

Following the summit conference, there was considerable enthusiasm in the U.S. for establishing the first biosphere reserves at the third annual ICC meeting in September 1974. To accomplish this, a good deal of work had to be accomplished in the three months available. Support from key Federal land managing agencies was garnered, in large measure through efforts of Dr. Jerry F. Franklin, chief plant ecologist at the Pacific Northwest Forest and Range Experiment Station of the Forest Service (U.S. Department of Agriculture) and Dr. Theodore Sudia, chief scientist of the National Park Service (U.S. Department of the Interior). To promote the effort internationally, the Department of State cabled U.S. embassies in 25 member countries on the ICC to request that they inform appropriate government officials of the intention of the United States to announce the establishment of biosphere reserves and to suggest that these countries might also wish to consider designating reserves according to the recently established UNESCO criteria (UNESCO, 1974).

Given the severe time constraint, the newly established US-MAB project directorate on biosphere reserves placed emphasis on selecting outstanding, securely protected examples of the ecosystems characteristic of the nation's biogeographic provinces which also illustrated either a substantial history of monitoring and ecological research or exceptional potential for such activities. It was recognized that,

under UNESCO guidelines, the ideal biosphere reserve should contain a large, strictly protected core zone for ecosystem conservation and long-term baseline ecological study, associated with a peripheral buffer zone to provide additional protection to the core as well as opportunities for experimental research. Unfortunately, it became apparent that few such ideal sites were available, owing largely to substantial differences in the management policies of Federal agencies administering candidate sites. Large conservation areas, eminently suitable as core zones, were primarily administered by the National Park Service. The candidates included some of the nation's finest National Parks--such as Glacier, Great Smoky Mountains, Olympic, Rocky Mountain, and Yellowstone. The agency's policies did not allow for experimental manipulation of natural ecosystems, except in certain limited cases, such as in controlled burning and exotic species control programs, where such research was deemed necessary to restore natural conditions and processes. Experimental research to enhance productivity and other economically beneficial characteristics was prohibited. In addition, the history of ecological study in many of these areas was limited. On the other hand, many areas with long histories of significant forest and range management research were administered by the Forest Service and the Agricultural Research Service (both within the Department of Agriculture). Most were relatively small sites within large tracts managed for sustained timber or livestock production. Although the experimental sites normally included small undisturbed natural areas, which served as controls, none contained the large undisturbed areas suitable for conservation of large-scale biological diversity. However, most had substantial demonstration and training programs, and their close association with economic interests and decisionmakers in the region were strong factors favoring biosphere reserve status.

Given these limitations, the Directorate developed the concept of multiple reserves, through which large conservation areas and much smaller experimental research areas

would be paired to fulfill the multiple purposes of the biosphere reserve in conservation, research, and training.

The United States announced its intention to establish an initial network of 16 biosphere reserves, most of them paired sites, at the I.C.C. meeting in September, 1974. It was joined by Austria, France, the Philippines, and the United Kingdom, and, shortly later, at a regional MAB meeting in Mexico City, by 13 Latin American nations. During the next two years, the Directorate continued to identify suitable sites, which were submitted to the I.C.C. for official UNESCO designation in accordance with a standard nomination procedure agreed upon at its fourth meeting in November, 1975. The initial network of 29 biosphere reserves in the United States, officially designated in June 1976, included representation from 15 of the nation's 20 biogeographic provinces, and paired sites in seven.

From 1976 through 1978, the US-MAB Directorate on Biosphere Reserves held five regional workshops which brought together scientific and administrative personnel from biosphere reserves, agencies, universities, and other institutions for the purpose of identifying needs, objectives, and specific projects for individual reserves, and for developing a framework for coordinating the activities of the reserves at the regional, national, and international levels (U.S. National Committee for MAB, 1976, 1977a, 1977b, 1977c, 1978). Separate work groups developed recommendations to enhance the role of the reserves in conservation of genetic diversity, research and monitoring, as well as education and training; and suggestions for completion of the network were presented. The workshops substantially increased understanding of the MAB biosphere reserves project within both the public and private sectors; and many of the more than 100 recommended projects were subsequently implemented by reserve administrators or carried out in the reserves by outside investigators. Major initiatives were undertaken to

synthesize information on biosphere reserves (Risser and Cornelison 1979), and to develop pilot programs for integrated pollutant monitoring (Wiersma, Brown, and Crockett, 1978; Brown, 1981). Since 1978, workshops have been held to develop separate guidelines for identification and selection of biosphere reserves in terrestrial and coastal areas (Fernald and others, 1981; Ray and others, 1981); to improve certain specific biosphere reserve functions, such as long-term ecological monitoring (U.S. National Committee for MAB, 1979) and public communication (in preparation); as well as to develop cooperative programs involving biosphere reserves in other nations, notably Mexico (U.S.D.A. Forest Service, in preparation) and the Soviet Union (Hemstrom and Franklin, 1981).

A MAB Consortium has been established for the purpose of providing grants for problem-oriented ecological research which furthers the mission objectives of three participating Federal agencies and four MAB Project Directorates (MAB 1, 2, 5, and 8). By signing the Consortium's charter, the Federal agencies agreed to fund the grant awards, which are made annually in amounts of up to \$60,000 for projects lasting up to three years. In the 1981 fiscal year, \$480,000 (U.S.) in grants were awarded, supporting 10 projects. The Consortium provides a unique vehicle for the United States to support innovative, relatively long-term, interdisciplinary, and often bilateral studies focused on the interrelationships between human activities and natural ecosystems--kinds of work which are often very difficult for agencies to carry out individually. The studies are intended to develop new perspectives on land use and management problems of regional, national, and sometimes international importance. With regard to the bilateral studies, it is worth noting that the Consortium funds the U.S. side of projects which have bilateral support. This distinguishes it clearly from technical assistance programs and promotes productive scientific relationships to which a substantial commitment exists on both sides. During the last two years, the Consortium has funded 11 research projects involving biosphere reserves.

CONDITIONS AND ACTIVITIES IN U.S. BIOSPHERE RESERVES

In order to provide an indication of the degree to which biosphere reserves in the United States are fulfilling their purpose, US-MAB conducted a survey of program managers in July 1981. A questionnaire was developed to provide information on scientific and related educational activities in each reserve, as well as the framework for its management, the relationship between its programs and anthropogenic threats, and its effectiveness as a conservation unit.

The questionnaire was mailed to the reserve manager in advance of its actual implementation, which was conducted by telephone from US-MAB's central office. The advance mailing gave the reserve staff time to gather relevant information and assure that the most knowledgeable individuals were involved. The use of a single MAB surveyor in making all calls helped make certain that respondents had a clear and uniform perception of what information was being requested. The survey technique yielded a timely and total response, although several calls were sometimes required to complete a particular questionnaire. Because the 10-page questionnaire was being implemented at the peak of the summer field season, telephoning may have saved respondents time. The personal contact certainly helped foster a willingness, and even enthusiasm, for participating in an effort which might otherwise have been viewed, at the least, as an inconvenience.

Although the survey methodology was designed to reduce variation in responses, we recognize that the respondent's knowledge and perceptions of the reserve's resources, problems, and programs can--and did--influence responses. Nevertheless, short of a comprehensive review of each reserve (which US-MAB does not have the administrative staff to execute), we believe that a uniformly administered survey provides a reasonable way to assess the overall strengths and weaknesses of the U.S. biosphere reserves as conservation, scientific, and educational resources.

Because the purpose of reserve administration is known to have a strong bearing on its use and management, we decided to group the U.S. reserves for analysis into two categories on the basis of predominant management emphasis. One group consisted of sites managed primarily for ecosystem conservation, such as national parks and monuments, national wildlife refuges, and equivalent reserves.

Research involving manipulation is restricted in these areas and is oriented toward restoration of natural ecological conditions or, in some cases, enhancement of natural fish and wildlife values. The reserves are administered by conservation bureaus within the Department of the Interior and private institutions. There are also two legislative wilderness areas administered by the USDA Forest Service. The 22 reserves in this group tend to be large, averaging 400,000 hectares in surface area (Figure 1, Table 1). The other group is managed primarily for experimental research oriented toward developing improved methods for sustaining or enhancing the productivity of managed ecosystems for human benefit. All are administered by Federal bureaus within the Department of Agriculture. The 14 experimental reserves generally are of moderate size, averaging 18,000 hectares in size.

In the following analysis, we present survey results and other information which provide perspective on the effectiveness of the U.S. biosphere reserves as sites for scientific study, education, and conservation of genetic and ecological resources. Our objective is to identify conditions and trends indicative of apparent problems and successes relating to the network as a whole. Individual reserves obviously may differ widely from the overall network in terms of their strengths and weaknesses, and we do not attempt to assess such differences, although particular reserves may be referenced in an illustrative context.

Table 1. Listing of Biosphere Reserves in the United States (as of August 1981)

<u>Name of Reserve</u>	<u>State</u>	<u>Biogeographic Province and Coastal Region (where applicable)</u>	<u>Administrator¹</u>	<u>Area in Hectares</u>	<u>Management Emphasis²</u>	<u>Year Designated by UNESCO (D=dedicated)</u>	<u>Misc.³</u>
Aleutian Islands National Wildlife Refuge	Alaska	Aleutian Islands (Aleutian-North Pacific)	FWS	1,100,943	C (E)	1976	
Beaver Creek Experimental Watershed	Arizona	Sonoran	FS	111,300	E	1979D	
Big Bend National Park	Texas	Chihuahuan	NPS	283,247	C	1976D	
Cascade Head Experimental Forest and Scenic Research Area	Oregon	Oregonian (Oregonian-Temperate Eastern Pacific)	FS	7,051	E	1976	IBP
Central Plains Experimental Range	Colorado	Grasslands - short grass	ARS	6,210	E	1976	IBP
Channel Islands National Park	California	Californian (Californian-Subtropical Eastern Pacific)	NPS	7,440	C	1976	
Coram Experimental Forest	Montana	Rocky Mountain - north	FS	3,010	E	1976D	IBP
Coweeta Hydrological Laboratory and Experimental Forest	North Carolina	Eastern Forest - south	FS	2,185	E	1976D	IBP LTER
Denali National Park	Alaska	Yukon Taiga	NPS	782,000	C	1976	
Desert Experimental Range	Utah	Great Basin - south	FS	22,513	E	1976	IBP
Everglades National Park	Florida	Everglades (Floridian-West Indian)	NPS	566,800	C	1976	
Fraser Experimental Forest	Colorado	Rocky Mountain - south	FS	9,328	E	1976	
Glacier National Park	Montana	Rocky Mountain - north	NPS	410,058	C	1976	

Table 1. Listing of Biosphere Reserves in the United States (as of August 1981) - Continued

<u>Name of Reserve</u>	<u>State</u>	<u>Biogeographic Province and Coastal Region (where applicable)</u>	<u>Administrator¹</u>	<u>Area in Hectares</u>	<u>Management Emphasis²</u>	<u>Year Designated by UNESCO (D=dedicated)</u>	<u>Misc.³</u>
Great Smoky Mountains National Park	North Carolina/ Tennessee	Eastern Forest - south	NPS	208,403	C	1976	
W. J. Andrews Experimental Forest	Oregon	Sierra Nevada- Cascade - north	FS	6,100	E	1976	IBP LTER
Haleakala National Park	Hawaii	Hawaiian (Insular-IndoPacific)	NPS	11,462	C	1980D	
Hawaii Volcanoes National Park	Hawaii	Hawaiian (Insular-IndoPacific)	NPS	92,934	C	1980D	
Hubbard Brook Experimental Forest	New Hampshire	Eastern Forest - northeast	FS	3,075	E	1976D	
Isle Royale National Park	Michigan	Eastern Forest - Canadian Taiga - transi- tional (Great Lakes)	NPS	54,144	C	1980D	
Jornada Experimental Range	New Mexico	Chihuahuan	ARS	78,297	E	1976	IBP
Konza Prairie Research Natural Area	Kansas	Grasslands - true prairie	TNC	3,487	C (E)	1979D	LTER
Luquillo Experimental Forest	Puerto Rico	Greater Antillean	FS	11,340	E (C)	1976D	
Niwot Ridge	Colorado	Rocky Mountain - south	FS	1,200	C	1979	IBP LTER
Noatak National Arctic Range	Alaska	Alaskan tundra	NPS	3,035,200	C	1976	
Olympic National Park	Washington	Oregonian (Oregonian-Temperate Eastern Pacific)	NPS	363,379	C	1976	

Table 1. Listing of Biosphere Reserves in the United States (as of August 1981) - Continued

<u>Name of Reserve</u>	<u>State</u>	<u>Biogeographic Province and Coastal Region (where applicable)</u>	<u>Administrator¹</u>	<u>Area in Hectares</u>	<u>Management Emphasis²</u>	<u>Year Designated by UNESCO (D=dedicated)</u>	<u>Misc.³</u>
Organ Pipe Cactus National Monument	Arizona	Sonoran - typical	NPS	133,278	C	1976	
Rocky Mountain National Park	Colorado	Rocky Mountain - south	NPS	106,710	C	1976D	
San Dimas Experimental Forest	California	Californian	FS	6,947	E	1976	
San Joaquin Experimental Range	California	Californian	FS	1,832	E	1976	IBP
Sequoia-Kings Canyon National Park	California	Sierra Nevada-Cascade - south	NPS	343,000	C	1976	
Stanislaus-Tuolumne Experimental Forest	California	Sierra Nevada-Cascade - south	FS	607	E	1976	
Three Sisters Wilderness	Oregon	Sierra Nevada-Cascade - north	FS	80,900	C	1976	IBP
University of Michigan Biological Station	Michigan	Eastern Forest - north central	University of Michigan	4,048	C	1979	
Virgin Islands National Park	Virgin Islands	Lesser Antillean (Floridian-West Indian)	NPS	6,130	C	1976	
Virginia Coast Reserve	Virginia	Eastern Forest - north- east (Virginian-MidAtlantic)	TNC	13,511	C	1979	
Yellowstone National Park	Wyoming, Montana, Idaho	Rocky Mountain - north	NPS	898,349	C	1976	

Table 1. Listing of Biosphere Reserves in the United States (as of August 1981) - Continued

<u>Name of Reserve</u>	<u>State</u>	<u>Biogeographic Province and Coastal Region (where applicable)</u>	<u>Administrator¹</u>	<u>Area in Hectares</u>	<u>Management Emphasis²</u>	<u>Year Designated by UNESCO (D=dedicated)</u>	<u>Misc.³</u>
Pending designation:							
Big Thicket National Preserve (12 units)	Texas	Austroriparian	NPS	34,217	C		
Guanica State Forest	Puerto Rico	Greater Antillean	PR		C		

¹ Abbreviations:

ARS - Agricultural Research Service (U.S. Department of Agriculture)
 BLM - Bureau of Land Management (U.S. Department of the Interior)
 FS - Forest Service (U.S. Department of Agriculture)
 FWS - U.S. Fish and Wildlife Service (U.S. Department of the Interior)
 NPS - National Park Service (U.S. Department of the Interior)
 PR - Commonwealth of Puerto Rico
 TNC - The Nature Conservancy

² Predominant management emphasis: C = conservation, E = experimental research. Strong secondary emphasis indicated in parentheses.

³ IBP - Research site for International Biological Program, 1965-1975

LTER - Pilot project site for long-term ecological research program of the National Science Foundation, 1980-

Figure 1. Biosphere Reserves in the United States



KEY

1. Hubbard Brook Experimental Forest
2. Virginia Coast Reserve
3. Everglades National Park
4. Great Smoky Mountains National Park
5. Coweeta Experimental Forest
6. University of Michigan Biological Station
7. Isle Royale National Park
8. Konza Prairie Research Natural Area
9. Big Bend National Park
10. Central Plains Experimental Range
11. Rocky Mountain National Park
12. Niwot Ridge
13. Fraser Experimental Forest
14. Jornada Experimental Range
15. Yellowstone National Park
16. Glacier National Park
17. Coronado Experimental Forest
18. Desert Experimental Range
19. Beaver Creek Experimental Watershed
20. Organ Pipe Cactus National Monument
21. San Dami Experimental Forest
22. Channel Islands National Park
23. Sequoia and Kings Canyon National Parks
24. San Joaquin Experimental Forest
25. Stanislaus-Toulumne Experimental Forest
26. H.J. Andrews Experimental Forest
27. Three Sisters Wilderness
28. Cascade Head Experimental Forest
29. Olympic National Park
30. Haleakala National Park
31. Hawaii Volcanoes National Park
32. Aleutian Islands National Wildlife Refuge
33. Montezuma National Preserve
34. Denali (Mt. McKinley) National Park
35. Juchillo Experimental Forest
36. Virgin Islands National Park

Nominated and Pending Designations:

- A. Big Thicket National Preserve, Texas
- B. Guanica State Forest, Puerto Rico

In our survey of the reserves, we asked field scientists to give us their perception of the adequacy of various scientific activities in the reserve to meet the present and reasonably foreseeable needs of scientists and managers. Activities were inventoried according to three broad types of scientific work: baseline information (30 activities), environmental monitoring (13 activities), and ecological research (39 activities). Each type of work was subdivided into a number of categories which provide the bases for analyses.

Baseline information was considered to include the cumulative record of bibliographies, photography and imagery, collections, resource maps, species checklists, environmental data banks, and data management systems available to support research and management of the reserve.

Environmental monitoring was defined as continuous, periodic, or cyclical measurements of physical and chemical parameters spanning or projecting to span five years or more. To assess the extent of cooperative monitoring activities, we asked respondents to identify national and international monitoring systems in which the reserves were participating and the parameters reported to the data bank, as well as to describe cooperative monitoring projects with other reserves, regional institutions, or nations. We also requested information on the nature of any development and testing of new monitoring methodologies in the reserves.

Ecological research was categorized into studies of vegetation and ecosystems (19 categories), wildlife (17), and soil ecology (3). Activities included a broad range of ecosystem studies as well as studies focused at the community and population levels. We asked respondents the same questions relating to cooperative activities as for environmental monitoring. In addition, we requested information on funding and staffing of the reserve during the last five

fiscal or calendar years, as well as on the reserve's scientific and related support facilities.

For each activity, the respondent was requested first to determine whether the activity applies to the reserve, and then to assign ratings to each applicable activity based on its adequacy to characterize particular ecosystem components and to enable natural and anthropogenic effects to be assessed and distinguished. In analyzing the survey data for each reserve, we calculated index ratings for each category as simple ratios of total points received for the activities under the category relative to the maximum possible point score for all applicable activities, converted to a 100-point scale. The index ratings were averaged over different types of scientific work, and over biosphere reserves managed primarily for conservation and experimental research. Tabulations of index ratings for each category by reserve are provided in Appendix A.

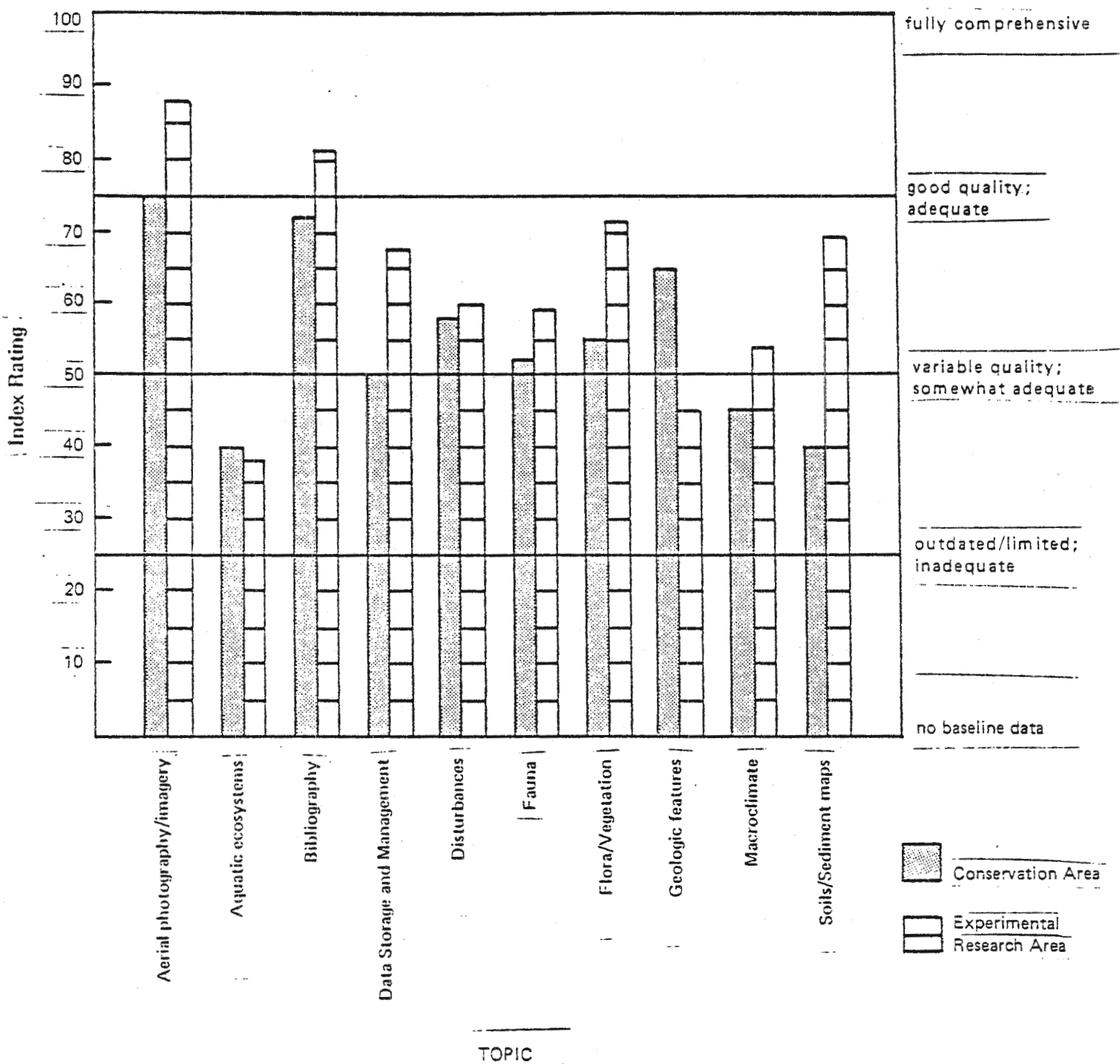
Baseline information. Figure 2 shows that although there exist some deficiencies in the quality of available baseline information and its adequacy to meet existing and foreseeable needs, a considerable base of knowledge is available for most of the reserves.

Overall, the index rating for experimental areas averaged 8 points higher than for conservation areas, which seems to reflect the generally longer history and greater intensity of study in these reserves. The index rating was much higher in experimental areas for soil and sediment maps (32 points difference), flora and vegetation (17 points), and data storage and management (17 points). With respect to particular activities within the categories, experimental areas scored dramatically higher in the adequacy of information on vegetation productivity (35 points difference), soil temperature and moisture (32 points), and weather

FIGURE 2

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Index Rating for Baseline Information in U.S. Biosphere Reserves.



data (25 points). A strong capability in each of these areas has been developed to support the forest and range research carried out in the experimental reserves. Experimental sites also recorded much higher scores for floristic checklists and keys (25 points difference). We do not have information on the scope of these materials in the experimental areas, although we do know from an earlier survey (Mack, and others, in press) that checklists in most of the conservation areas are relatively complete for vascular plants, but are inadequate for other groups. We suspect, therefore, that the reported difference could be due either to actual deficiencies associated with difficulty in developing comprehensive checklists for the much larger conservation area reserves, or to an enhanced awareness of deficiencies on the part of conservation area respondents because of their extensive use of such information in research related to species conservation.

Conservation areas scored strongly higher (by 20 points) only in the geological features category, for which scores averaged much higher in all surveyed activities--surficial geology, topographic maps, seismic activity, and unusual substrate chemistry. Conservation areas also reported a substantially higher average rating for air quality data (by 15 points), although the average rating for the macroclimate category was lower than for the experimental areas. These differences may be in part attributable to the need for geological information and air quality information in planning for development and public use in the large conservation areas, most of which are also units of the National Park System. They may also reflect a somewhat greater need for these types of data in developing programs for conservation, natural history interpretation and threats mitigation in large natural ecosystems, than in the smaller production-oriented experiment sites.

Regardless of their predominant management emphasis, the reserves reported major inadequacies in baseline information for water resource parameters. Several of the reserves reported no available baseline information for one or more activities, and the majority reported that available information for most or all activities is either of limited utility in scientific and management applications, or applicable only in highly specific areas. Very low scores were recorded for groundwater hydrology, in which only one reserve reported a comprehensive data base. The most complete data bases were reported by reserves conducting nutrient cycling studies (H.J. Andrews, Hubbard Brook, Great Smoky Mountains, and Coweeta) and those having major aquatic ecosystem research programs (Everglades and the Univ. of Michigan Biological Station).

Considering all 10 categories surveyed, only 11 reserves had no index ratings indicative of a seriously inadequate data base (≤ 25). Twelve reserves had such ratings for one category, seven reserves for two, four reserves for three, and three reserves for four or more. Thus, significant gaps exist even for reserves reporting a generally adequate information base for most baseline information categories.

The average index ratings for baseline information were slightly greater than for long-term environmental monitoring, and much greater than for ecological research, in both conservation and experimental areas. The relationship between the index ratings for the three types of work was relatively consistent, whether the ratings for the reserves were high or low. This relationship may be due in part to the broad utility of many baseline information categories in planning and management--a condition which encourages funding--and to the fact that such information is often collected as a major effort around the time a protected area is established by legislation or administrative action. There is also a tendency for site administrators to delay initiation of long-term monitoring and research

until a particular management problem requires them. Lack of emphasis on early detection and prevention of adverse changes in ecosystem structure and function would almost certainly result in deficiencies in these types of work.

Long-term environmental monitoring. Long-term environmental monitoring illustrated patterns similar to baseline information (Figure 3). Most of the reserves are conducting long-term monitoring of physical and chemical parameters of the environment as well as disturbance. Most reserves report substantial inadequacies in one or more of the surveyed categories, although these were generally less pronounced in experimental areas, which averaged 11 points higher than the conservation areas. Major differences were recorded for natural disturbances (25 points higher in experimental areas), soil temperature (23 points higher), aerial imagery (20 points higher), weather and air quality data (17 points higher), physical water parameters (15 points higher), and land use changes (15 points higher). Only in the monitoring of seismic activity did the conservation areas score higher (by 28 points). These results indicate that long-term environmental monitoring is given much greater emphasis in experimental reserves. The Coweeta Experimental Reserve's index rating of 91 for this type of work was the highest overall rating in the survey.

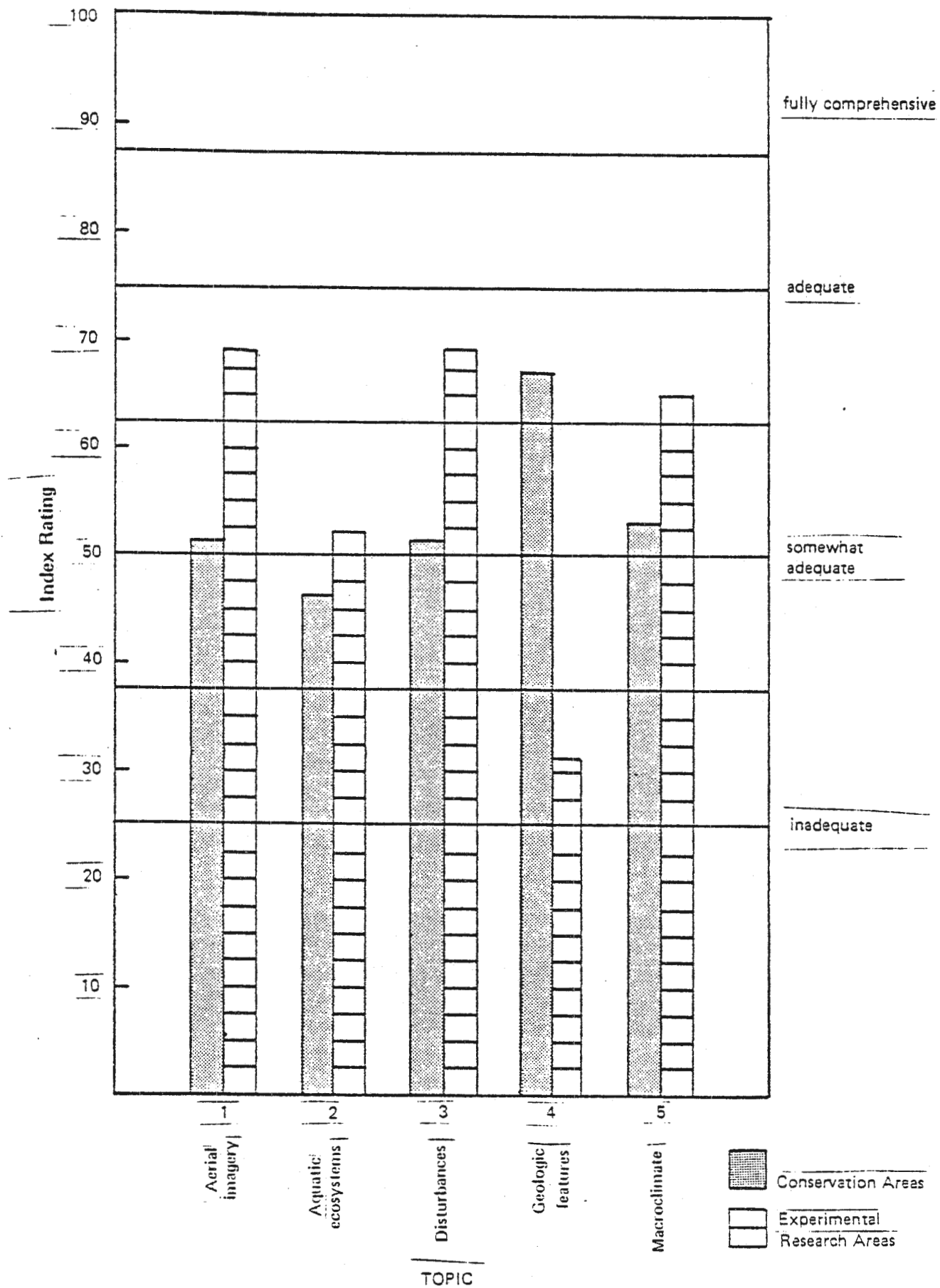
Although monitoring of water resource parameters was viewed as incomplete in most reserves, index ratings were generally higher than those reported for baseline information for nearly all activities, and in many cases substantially higher (e.g., an 18 point higher value for water chemistry in experimental areas). The results seem to indicate that measures are being taken in many areas to fill the substantial gaps in existing data bases through long-term monitoring activities.

Monitoring activities with index ratings of 74 or higher were considered adequate to meet most known or reasonably foreseeable information needs. A large percent-

FIGURE 3

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Index Ratings for Longterm Environmental Monitoring in U.S. Biosphere Reserves



age of the respondents rated monitoring activities in one or more categories at this level. The number of reserves (out of 36) reporting such ratings was 13 for aerial imagery, 12 for disturbance, 11 for macroclimate, 4 for water resources, and 6 for seismic activity.

The integration of monitoring activities into national and international systems was substantially less than expected. Twenty of the reserves administer official U.S. Weather Bureau stations which report data to the National Climatological Data System, the oldest and largest of the major national environmental data banks. Nineteen reserves are monitoring atmospheric wetfall and dryfall deposition as part of the National Atmospheric Deposition Program, which is administered by the U.S. Environmental Protection Agency (EPA). Two are officially designated as national air quality monitoring sites, and transmit data to the EPA's National Aerometric Data Bank. Seven report information on stream flow, water stage, or groundwater levels to the National Water Data Systems administered by the U.S. Geological Survey (USGS), and one reserve is a part of USGS's National Stream Quality Accounting Network, which is creating a national data bank to characterize conditions and trends in stream water quality. No reserves are presently participating in UNEP's Global Environmental Monitoring Programme. The comparability, utility, and cost-effectiveness of many monitoring activities in the reserves could be substantially improved through standardization of methodologies and integration into national and international monitoring systems. In view of the large amount of monitoring now being undertaken, opportunities are significant.

Involvement of U.S. biosphere reserves in cooperative environmental monitoring projects with regional institutions, other biosphere reserves, and other nations is confined primarily to air quality, water quality, and hydrological studies.

Perhaps the most comprehensive regional effort is the Everglades water management project, through which Federal and local government agencies have developed a coordinated environmental and biological monitoring system to provide a framework for allocating south Florida's surface water resources to agricultural, urban, and conservation uses. In particular, the project regulates the flow and maintains the quality of the perennial sheetflow, which largely determines the productivity and diversity of the wetlands and estuarine ecosystems of the Everglades Biosphere Reserve. To help assess and deal with known and suspected threats related to air pollution, the Great Smoky Mountains, Olympic, Organ Pipe Cactus, and Sequoia-Kings Canyon Biosphere Reserves are cooperating with a variety of government agencies and universities in regional air quality monitoring projects. The Olympic Biosphere Reserve is also working with other agencies and tribal organizations in monitoring stream flow conditions and anadromous fish populations in regional streams originating in the reserve, in order to provide an improved basis for fisheries management.

Only one cooperative environmental monitoring project involving two biosphere reserves was reported: an effort by the Rocky Mountain and Niwot Ridge Biosphere Reserves to carry out coordinated monitoring of air quality and atmospheric deposition, in order to provide a basis for assessing impacts on the ecosystems of the Rocky Mountains near the rapidly developing Front Range megalopolis. Additional monitoring involving paired reserves is being carried out in connection with cooperative research projects, which are described briefly in the next section.

With regard to bilateral monitoring activities, the Glacier Biosphere Reserve reports involvement in a cooperative US-Canada project to evaluate the ramifications of acid precipitation, which is becoming a serious international environmental problem over much of the industrialized region on both sides of the border.

A bilateral pollution monitoring project involving paired biosphere reserves in the United States (Isle Royale and the Univ. of Michigan Biological Station) and the Soviet Union (Berezinsky, Sary-Chelek, and Prioksko-Terrasny Biosphere Reserves) is being planned under the 1974 bilateral agreement on Cooperation in the Field of Environmental Protection. Two joint symposia on biosphere reserves have been held, the most recent one in March 1980. The latter meeting resulted in agreement on the desirability of cooperation in pollutant monitoring and assessment of pollutant effects, as well as in research on ecological succession processes. A visit of U.S. scientists to the Soviet reserves to enable inter-calibration of Soviet and U.S. equipment and initiate the cooperative field monitoring and research effort has been agreed to (Sokolov 1981), although its scheduling remains to be arranged.

Finally, the U.S. Biosphere Reserves are involved in research and development leading to improved monitoring techniques. Experimental methods now being developed include testing of solar powered units for monitoring heavy metal deposition (Olympic Biosphere Reserve), satellite telemetry systems and biomonitoring of fish reproduction under varying conditions of environmental stress such as acid rain (Great Smoky Mountains Biosphere Reserve), and experimental three-dimensional modelling to enable improved prediction of hydrological and water quality changes (Everglades Biosphere Reserves).

Ecological research. Most biosphere reserves in the United States have a long history of ecological investigation. Many have served as preeminent sites for carrying out certain kinds of programs. For example, the Jornada Experimental Range in New Mexico, an IBP site, has been a center for studies to improve the sustainable productivity of warm desert grasslands for more than 65 years. The Hubbard Brook Experimental Forest is globally recognized for its contributions to our understanding of changes in the structure and function of deciduous forest

ecosystems following timber harvest, as well as in the development of techniques for utilizing small watersheds as basic units for ecological study. The Everglades National Park has become a leading site for the study of the interrelationships between the quantity and quality of surface water and the diversity and productivity of plant and animal populations in a tropical wetland ecosystem. The Luquillo Experimental Forest is a world center for basic and applied research on the dynamics of undisturbed and managed forest ecosystems in the humid tropics. In fact, somewhat more than half of the reserves are carrying out major scientific programs, typically developed over a period of decades, to support the improved management of natural and manipulated ecosystems. Reserves which presently lack such programs usually have a substantial record of individual studies conducted to meet particular research and management needs. However, even the most comprehensive program is influenced strongly by the particular objectives of the reserve administrator which determine the subjects studied and, equally important, those not studied. These objectives may not necessarily be fully in harmony with the mission of the biosphere reserve to provide an understanding of conditions, cycles, and directional changes at the population, community, and ecosystem level, as well as the effects of human activities on them.

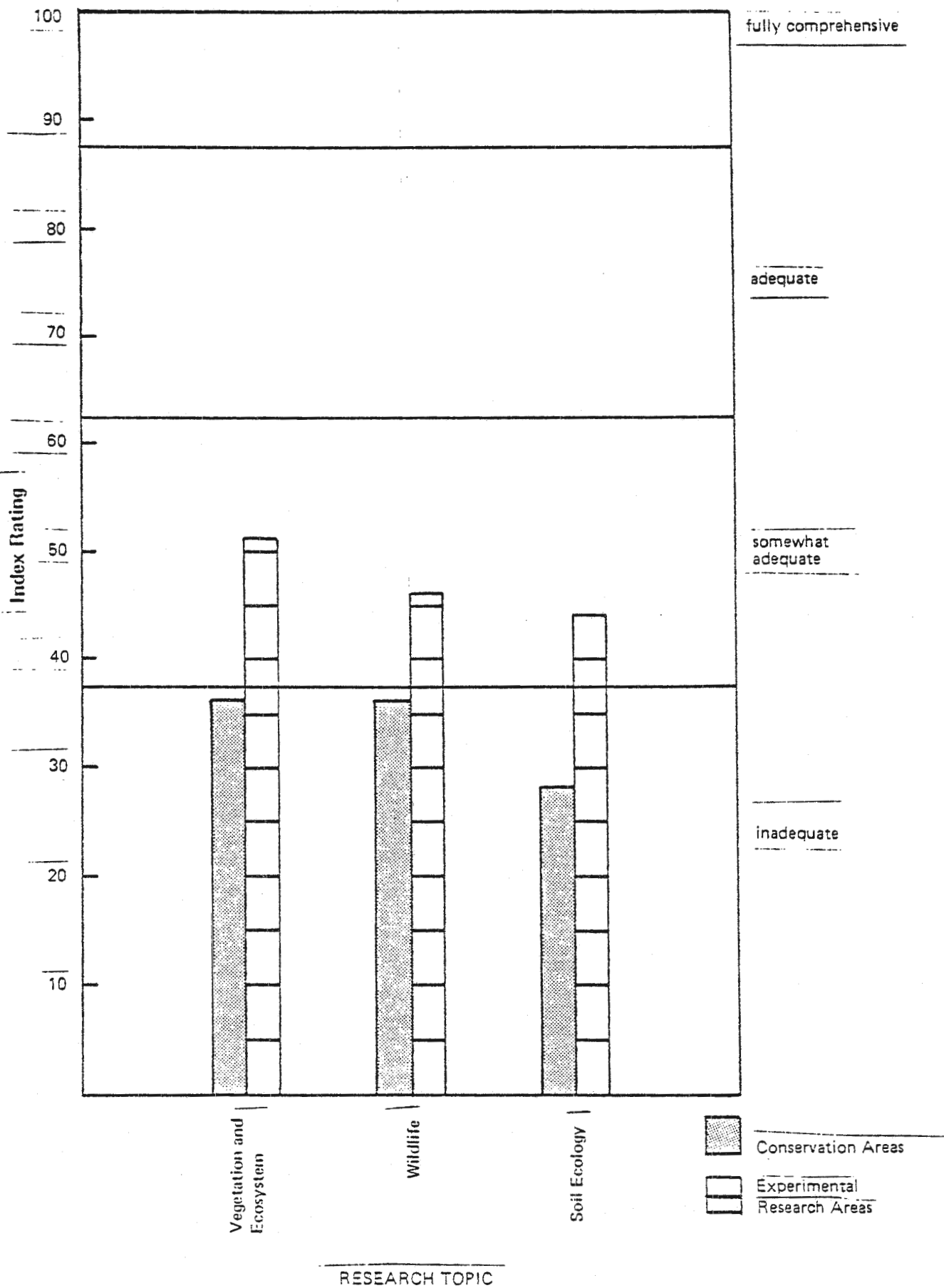
Survey respondents reported major inadequacies in the research programs of most of the reserves to provide information needed to support effective science and management programs. Overall index ratings for ecological research in individual reserves were in or near the "adequate" range (≥ 55) only for a few major centers of integrated ecosystem research, notably Hubbard Brook (66), the University of Michigan Biological Station (63), H.J. Andrews (60), Beaver Creek (57) and Coram (55). Overall ratings indicative of numerous deficiencies (≤ 38) characterized 15 of the 20 conservation areas, but only three of the 16 experimental areas (see Appendix A, Table 3a). Average index ratings for all major categories of research fell in the "somewhat inadequate" range for the experimental areas and

in the "inadequate" range for the conservation areas (Figure 4). Average ratings at or near the adequate range (≥ 55) were recorded for only six of the 36 reserves for vegetation and ecosystem studies, five for wildlife studies, and three for soil ecology studies. Ratings were lower in 75% of the reserves for soil ecology studies than for both vegetation and wildlife research, which were variable in their relationship. Soil ecology ratings were at the bottom of the inadequate range in all but four of the conservation areas, but such low ratings were reported for only two of the experimental areas. Ratings in the inadequate range (≤ 38) were recorded for all three research categories in 12 of the conservation areas, including 10 of the 15 areas in the U.S. National Park System, but in only one of the experimental areas.

Index ratings for research activities within the research categories appear to reflect the priority of particular lines of investigation in fulfilling the purpose of the reserves. For example, in the production-oriented experimental areas, ratings at or near the adequate range (≥ 55) were reported for tropical forest resoration and management studies (100), productivity studies (70), silvicultural studies (65), succession studies (65), ecosystem modelling (55), grazing impact studies (55), nutrient cycling studies (55), and the population dynamics of large mammals (55). In the conservation areas, no activities fell in this range, although ratings in the somewhat adequate range (38-63) were reported for fire ecology (50), tropical forest resoration (50), rare and endangered plant (48) and animal (45) populations, succession studies (48), grazing impact on vegetation (45), visitor impact on vegetation (45), exotic species control for animals (43) and plants (40), acid precipitation impact studies (40), and the population dynamics of large mammals (45), fish (45), resident birds (45), and migratory birds (38).

FIGURE 4

Index Ratings for Ecological Research in U.S. Biosphere Reserves



Ratings were higher in experimental areas for most activities. The survey respondents from conservation areas perceived a greater degree of adequacy only for visitor impact studies, exotic species control studies, population dynamics of rare and endangered species, ethnobotanical and ethnozoological studies, and genetic resources management studies. All of these lines of inquiry relate to matters of major concern in conservation and public use areas. It is disturbing that these respondents reported average ratings in the inadequate range for about half of the major animal groups, for all modern lines of ecosystem study (carbon and nutrient cycling, energy flow studies, and ecosystem modelling), and for investigations relating to the detection and assessment of threats from air pollution and land use changes. Major deficiencies in these important activities provide considerable reason for concern that the support of conservation area administrators for scientific inquiry is insufficient to provide the basis for informed management of most of the conservation areas, as they become more genetically and ecologically isolated, and subjected to intensifying human influences in the decades ahead.

The survey responses indicated that 19 of the 36 biosphere reserves are participating in cooperative research at the regional level, ten are conducting projects in cooperation with another biosphere reserve, and only two are cooperating in bilateral projects, both with Mexico. Conservation and experimental areas are involved about equally in cooperative activities, which include population, community, and ecosystem studies.

At the regional level, the Great Smoky Mountains and Coweeta Biosphere Reserves, along with the Oak Ridge National Laboratory, form an integrated cluster of research sites in the deciduous forests of the Southern Appalachian Mountains. Cooperation is continuing and extensive, and presently is focused on nutrient cycling studies and the ecology of the European wild boar. An important project

of national scope involves the H.J. Andrews Biosphere Reserves in the Sierra Nevada-Cascade biogeographic province which is carrying out coordinated productivity and community structure studies with biosphere reserves in the eastern deciduous forest, grasslands (true prairie), and Rocky Mountain provinces. At the international level, the Beaver Creek Biosphere Reserve in the U.S. and La Michilia Biosphere Reserve in Mexico are conducting multi-institutional studies of upland pine-oak forests in the Sonoran biogeographic province. On-going activities focus on the dynamics of white-tailed deer populations, ecological data management, small watershed studies to improve multiple use benefits, and the development of ecosystem models. A joint publication on the project is planned. Through this project, productive professional relationships have been established between scientists in both countries. These relationships created a favorable climate for convening a major workshop in April 1981 on wildlife and range research needs in northern Mexico and the southwestern United States. The workshop involved the participation of three US-MAB project directorates (nos. 2,3 & 8), and brought together scientists and government administrators concerned with conservation and land management problems in the Sonoran, Madrean-Cordilleran, and Chihuahuan biogeographic provinces. The workshop resulted in agreement on a number of specific cooperative undertakings in wildlife habitat management, range management, and technology transfer, and established a framework for future bilateral activities in the region. Many of the workshop recommendations, particularly relating to joint development of information systems, are underway.

Twelve of the reserves are involved in development and testing of new research methodologies for specific applications, including satellite monitoring of arid lands (Desert Experimental Range), the beta attenuation method for above ground biomass determination (Konza Prairie), native plant recovery methods (Hawaii Volcanoes), and radio tracking of alligators and crocodiles (Everglades).

In 1980, four of the reserves (Table 1) received large multi-year grants from the National Science Foundation (NSF) to establish pilot long-term ecological research programs (LTER), and two additional reserves are now being considered for funding. This program focuses on improving understanding of ecosystem dynamics, with particular emphasis on the pattern and control of primary production, trophic level interactions, nutrient cycles, organic matter accumulation, and the effects of natural and anthropogenic disturbances on these ecosystem functions. The LTER program will greatly improve the scope of monitoring and research in selected biosphere reserves. It will also provide for improved cooperation among selected sites through a coordinating committee of principal investigators to provide continuing oversight. This committee is also responsible for communicating the study results to potential users, thereby addressing a common deficiency in ecological research programs. The LTER program was developed following a series of multidisciplinary workshops sponsored by NSF in 1977 and 1978 (Botkin and others, 1977, 1978), and is being planned and administered by the scientific community as an experimental undertaking to develop improved methods for characterizing and evaluating ecosystem processes. Although the methodologies and information generally will support improved ecosystem management, the orientation of the prototype studies is scientific rather than managerial. The next grant awards, scheduled for January 1982, should increase the existing six-site LTER program to approximately 10 sites reflecting a representative diversity of the nation's biomes.

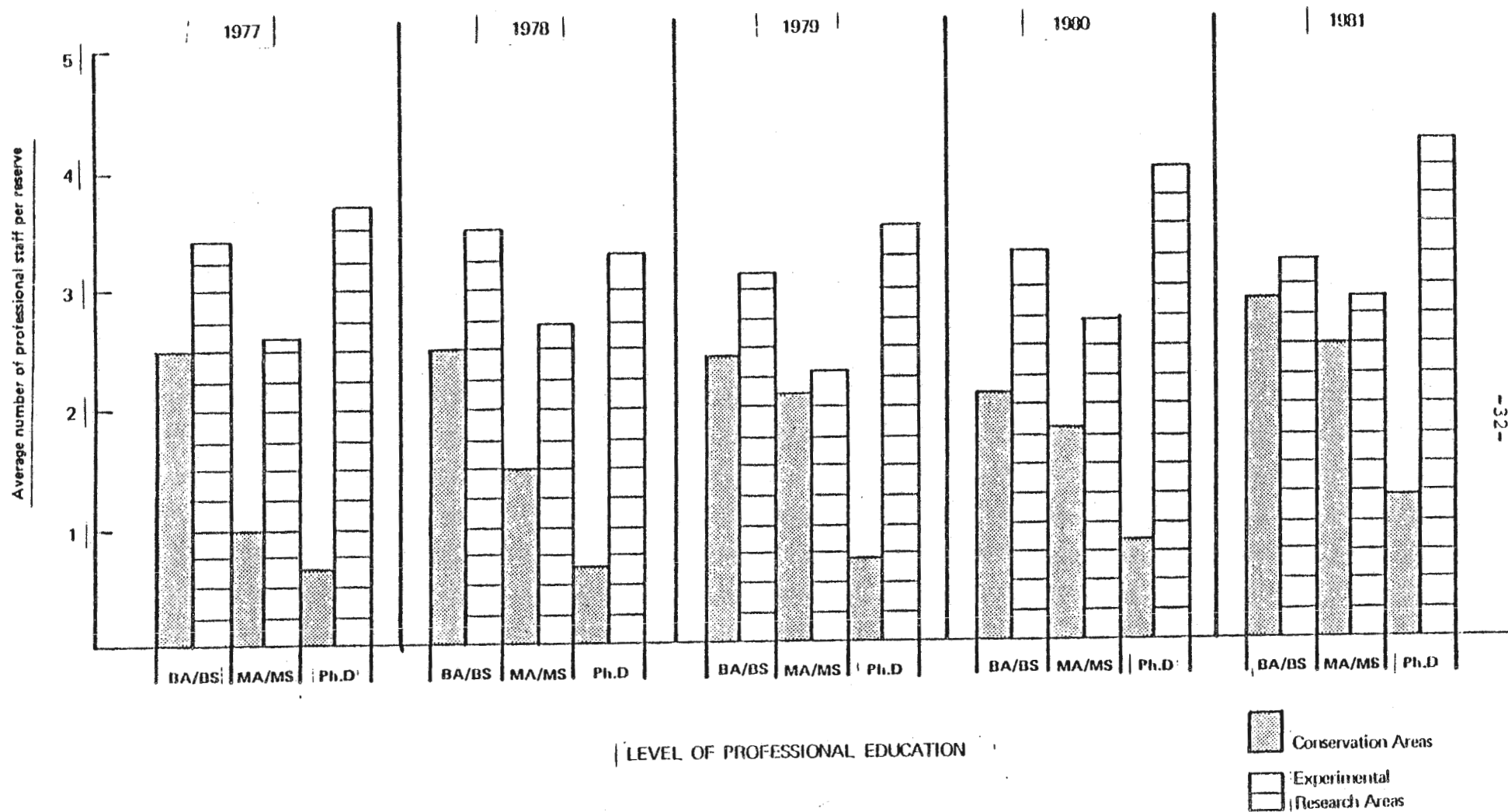
Facilities, Staffing and Funding

Our survey results indicate that a reasonable level of basic facilities to support scientists' work are available in most, but not all, of the biosphere reserves.

Provision of lodging and field station facilities in the reserve itself can serve as a major inducement for use of the reserve for scientific study. Twenty-five of the 36 reserves can provide lodging accommodations; 28 have permanent field stations, including 20 with "dry" lab and 15 with "wet" lab facilities. Most reserves have permanent plots for long-term observational and, in the experimental areas and a few conservation areas, manipulative research. We do not have information on library and specific data processing capabilities, although we know that facilities exist in most areas, but operations vary widely in adequacy.

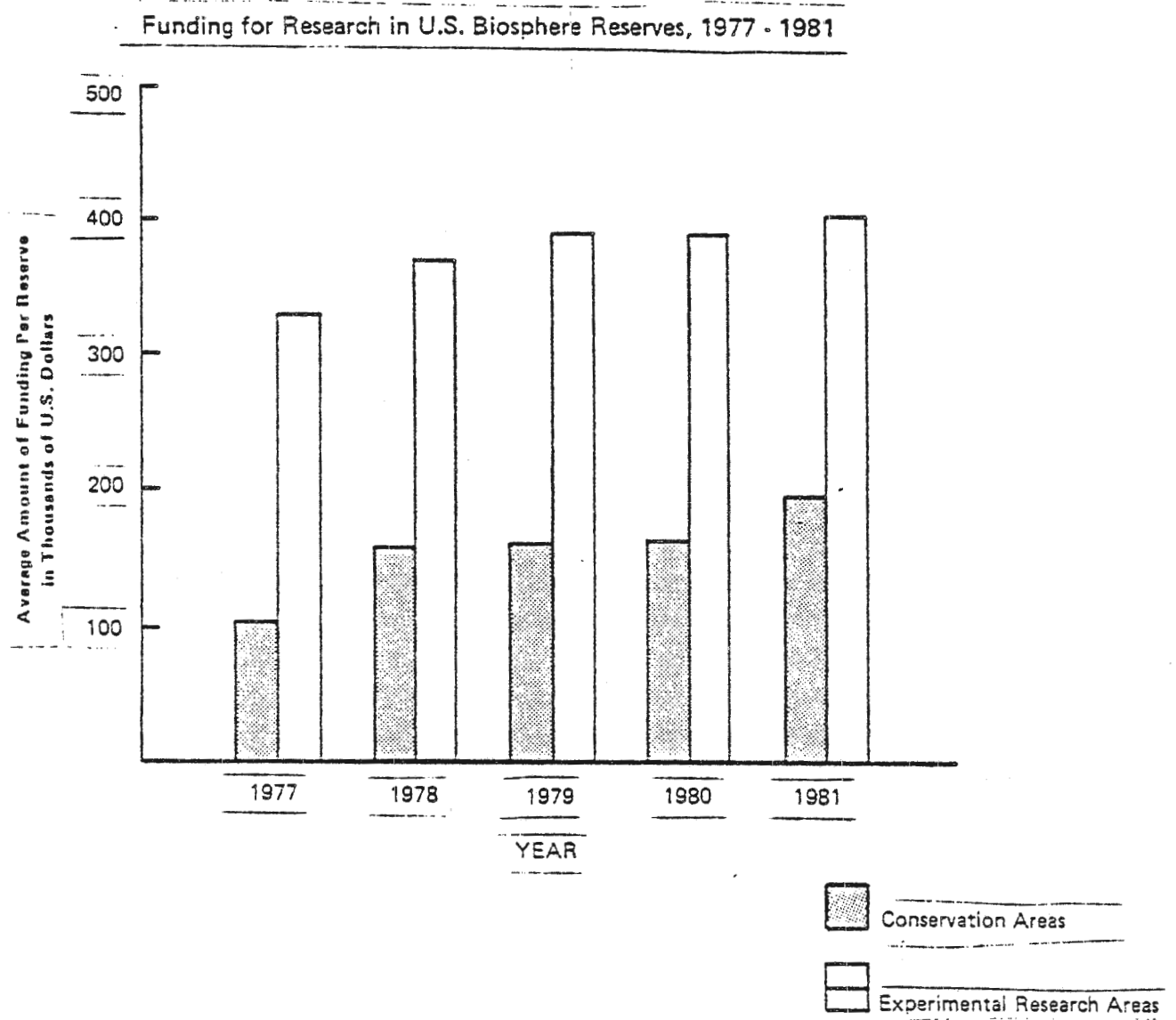
Figure 5 shows trends during the last five years in the average number of scientific staff positions, by education level, for conservation and experimental areas. The results demonstrate steady improvement in staffing, particularly for masters and doctoral level personnel in the conservation areas. Staffing generally showed small increases for the experimental areas, although there were minor year-to-year variations in the direction of changes. In 1977, 9 of the 13 reporting experimental reserves employed one or more doctoral level scientists. In 1981, the number had risen to 10. On the other hand, in the conservation areas, such personnel were employed in 5 of 18 reporting areas in 1977. In 1981, the number was 12. A similar trend applies to masters level personnel. The data suggest that, even though conservation areas lag far behind experimental areas in staffing, conservation area administrators are giving considerable attention to the development of in-house scientific capability, presumably to provide information to help deal with increasing human-caused threats to these areas. There is an obvious positive relationship between a large science staff and high average index ratings for science programs. The seven reserves with the largest scientific staff (≥ 10 positions) all fall within the top rated sites (index values ≥ 60). However, although reserves with small

Professional Staffing of U.S. Biosphere Reserves, 1977-1981



(≤3) or no science staffs tended to report low index ratings, there was considerable variation in these ratings, perhaps due to differences in the use of the reserves by outside investigators. Thus, it appears that a large multidisciplinary staff capability is consistently associated with exemplary science programs, but that the lack of a large staff does not necessarily assure serious inadequacies.

Since 1977, the average funding level for scientific study in biosphere reserves has increased about 22% in the experimental areas and about 93% in the conservation areas (Figure 6). The survey data indicate significant growth, after adjustment for inflation, in the average budget for the conservation areas and a slight decline for the experimental areas. In 1977, experimental areas were three times better funded than the conservation areas. By 1981, they differed by only a factor of 2. Increasing support by the National Park Service for research in the large national parks appears to have been the cause. In 1981, no funding was allocated for scientific study in two areas (Stanislaus-Tuolumne Experimental Forest and Noatak National Reserve). Funding elsewhere was between \$10,000 and \$100,000 (U.S.) in 12 reserves, \$101,000 and \$400,000 in eight, \$501,000 and \$1 million in four, and more than \$1 million in two (H.J. Andrews Experimental Forest and Everglades National Park). The six best funded reserves are all Federally administered and all received high index ratings for overall adequacy of their scientific programs. Only the University of Michigan Biological Station received a higher rating, presumably because of its long history of research by independently funded investigators. During the five-year period surveyed, three reserves (Channel Islands National Park, Three Sisters Wilderness, and Virgin Islands National Park), all designated in 1976, received funding for the first time. Although the large differences among reserves limit the value of generalizations, the data suggest that a "typical" biosphere reserve in the United States has accommodations and laboratory support facilities, supports



about eight staff positions including 2-3 doctoral level scientists, and has an annual science budget of about \$300,000 (U.S.).

Anthropogenic Threats and Effectiveness in Conservation

In 1980, at the request of the Congress, the National Park Service prepared a preliminary assessment of the magnitude and extent of threats to units of the National Park System in order to provide a basis for developing a systematic strategy for their detection, prevention, and mitigation (National Park Service, 1980). Threats were defined as "those pollutants, visitor activities, exotic species, industrial development projects, etc., which have the potential to cause significant damage to park resources or to seriously degrade important park values and experiences." The assessment was based primarily on the results of a survey of the managers of each of the 326 units in the System. The managers were requested to provide information on 76 threats in seven categories: aesthetic, degradation, air pollution, exotic encroachment, operations, physical removal of resources, physical impacts of visitor activities, and water pollution and hydrology. Respondents were asked to indicate whether the source of each threat originates within or outside the park, whether the threat is known or suspected, whether documentation by scientific study is required, and whether a strategy for addressing the threat is included in a management plan.

The survey results indicated a wide range of threats of both internal and external origin, affecting all types of ecosystems. The greatest number of threats--nearly twice the systemwide average--was reported for large natural areas more than 4,000 hectares in size. Disappearance of surrounding buffer zones due to "external encroachment" was cited as a major influencing factor. The 12 NPS-administered biosphere reserves existing at the time of the survey reported an average of 36 threats, nearly three times the servicewide norm. The result was considered to reflect the greater capability of these areas to detect and evaluate threats because of the existence of substantial monitoring and research capabilities, and

suggested that many threats in other areas may have been overlooked. The fact that about 75% of the servicewide total of reported threats was considered to be inadequately documented by research would seem to support this conclusion.

In order to obtain up to date information on all biosphere reserves in the United States, the MAB survey utilized the NPS format, but included only those threats having their principal potential impacts on natural ecosystems, rather than visitor experiences. Information was requested on 49 threats in all of the categories used by NPS except for aesthetic degradation. Table 2 provides an overview of the extent to which each of the surveyed threats was reported as a known or suspected problem in the biosphere reserve network. The results show that the threats affecting the reserves are many and widespread, and that the majority of reserves in the network is affected or potentially affected by two or more threats in each category. For 82% of the threats, a known or potential problem was indicated by a greater percentage of conservation than experimental areas. Much greater percentages of the conservation areas ($\geq 20\%$) reported threats for the majority of operations categories; illegal collection of biological and archaeological material, visitor-caused soil erosion and wildlife disturbance; exotic animals and plants; and water quality impacts from sewage, toxic materials and oil spills. Most of these differences appear to reflect the management emphasis on visitor use in the 15 national park system areas, resulting in a higher probability of impacts associated directly with visitor activities, and development and park operations related to these activities. More frequent reports of exotic species problems may be a function of the much larger size of these areas, and possibly a heightened awareness of such problems by conservation area respondents. Site-specific data clearly show that the differences in threats from oil spills were due to the much larger number of coastal sites in the conservation area group. A greater percentage of reporting experimental areas

Table 2 Percent of Biosphere Reserves Reporting Particular Threats (August, 1981)

<u>Percent of Biosphere Reserves Reporting Documented or Suspected Threat</u>			
<u>Threat</u>	<u>All Reserves (n=36)</u>	<u>Conservation Areas (n=22)</u>	<u>Experimental Areas (n=14)</u>
AIR POLLUTION			
Acid rain	78%	52%	71%
CO ₂	56	59	50
CO	61	59	64
(CH ₃) _x	69	73	64
NO _x	67	66	64
Radioactivity	39	36	43
Other	50	64	29
EXOTIC ENCROACHMENT			
Animals	61	73	43
Plants	67	68	64
Unnatural fire	72	73	71
Weather modification	19	23	14
Other	0	0	0
OPERATIONS			
Employee ignorance	44	59	21
Facilities	44	59	21
Inadequate management plan	42	55	21
Misuse of biocides	28	17	29
Political pressure	53	59	43
Research	47	50	43
Roads and utilities	69	77	57
Suppression of natural fire	64	68	57
Trails	50	59	36
Other	0	0	0
PHYSICAL REMOVAL OF RESOURCES			
Archaeological resources	53	59	43
Fishing	67	73	57
Grazing	61	64	57
Hunting	67	59	79
Logging	36	18	64
Mineral extraction	42	36	50
Oil and gas	22	23	21
Soil erosion	72	68	79
Specimen collection	58	64	50
Other	8	9	7
PHYSICAL IMPACTS OF VISITOR ACTIVITIES			
Campfires	64	73	50
Erosion	67	77	50
Habitat impacts	47	50	43
Off-road vehicles	50	55	43
Subtle influences	31	32	29
Trampling	56	59	50
Impacts on wildlife	67	77	50
WATER POLLUTION/HYDROLOGY			
Acid mine drainage	14	18	7
Changes in geothermal features	22	27	14
Chemical pollution	36	36	36
Erosional deposition of sediment of salt	33	27	43
Oil spills	22	36	0
Radioactivity	22	18	29
Sewage pollution	28	41	7
Toxic materials spills	22	36	0
Unnatural flooding or decrease in surface flow	42	54	36
Other	19	32	0

applied to only nine threats, and substantially greater percentage (>20%) only for hunting and logging--both activities which are not legally permitted in the conservation areas.

Not only are more threats reported for conservation areas, but a greater percentage of the reported threats for all categories are being addressed through a science or management program than in experimental areas (Figure 7). The increased attention to threats applies to internal and external, as well as documented, suspected, and known but undocumented threats. Intergroup differences exceed 30% for all categories except air pollution, which is being addressed by a relatively small and about equal percentage of reserves in each group. The regional nature of this problem and the difficulty of addressing it through programs within the reserves may be a contributing factor in the much lower percentage of conservation areas reportedly addressing these threats.

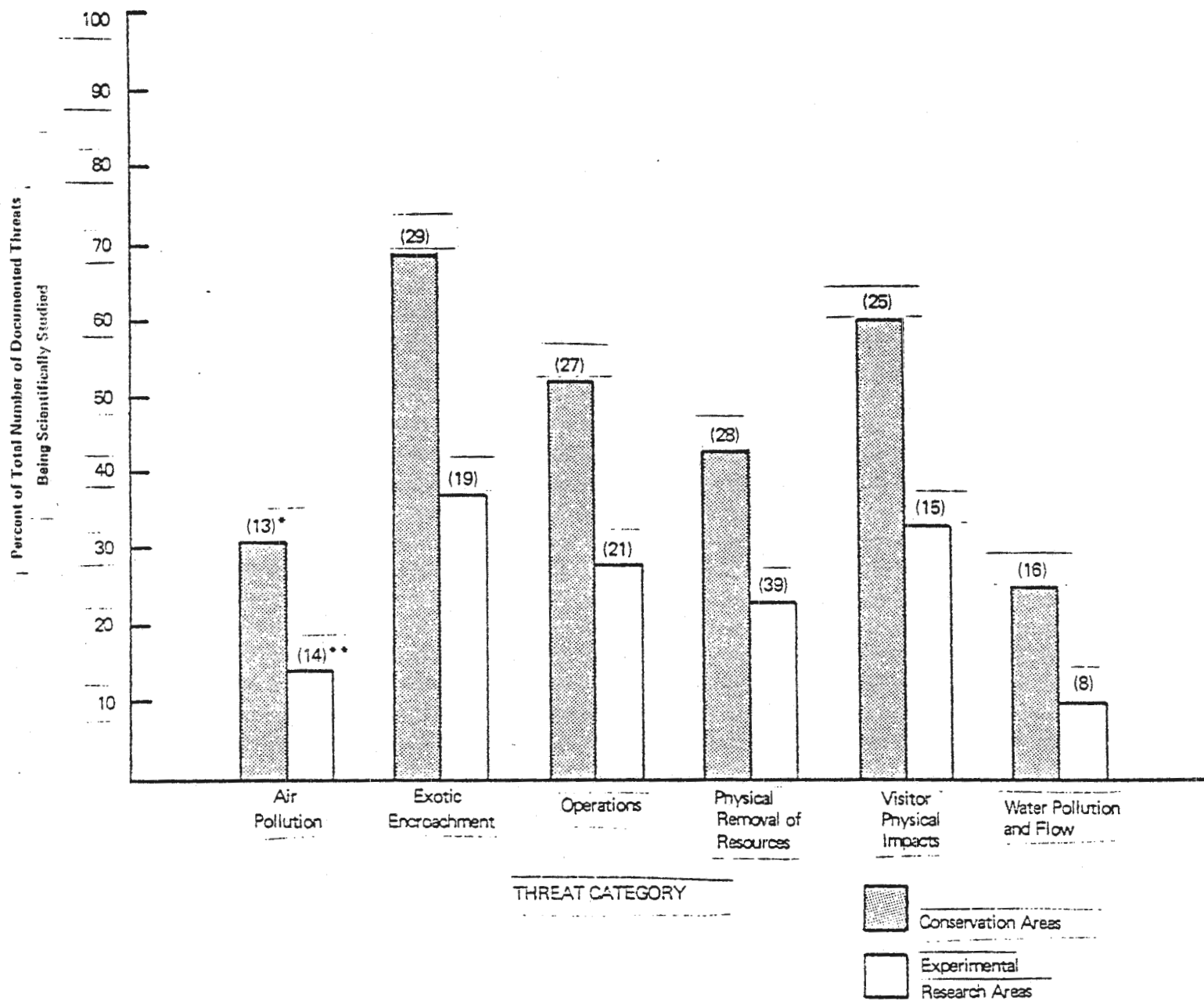
The overall survey results suggest that, although science programs are rated as much less comprehensive in the conservation areas, they are much more likely to be focused on detection and assessment of anthropogenic threats than in experimental areas. The growing number and seriousness of such threats, and the increasing awareness of this trend by conservation area administrators, has most likely been responsible for rapid closing of the gap between conservation and experimental areas in terms of staffing and funding for scientific study.

The conservation areas differ widely in the level of anthropogenic threat to which they are, or may be, subjected. We rated each reserve based on the status of reported threats, with declining rating values being given to known and scientifically documented threats, known but undocumented threats, suspected but undocumented threats, and threats not presently a problem, in that order. On this basis, we determined that the reserves receiving the highest ratings--and there-

FIGURE 7

-39-

Status of Scientific Documentation for Reported Threats to U.S. Biosphere Reserves



*total number of documented threats reported for 20 conservation areas.

**total number of documented threats for 16 experimental areas.

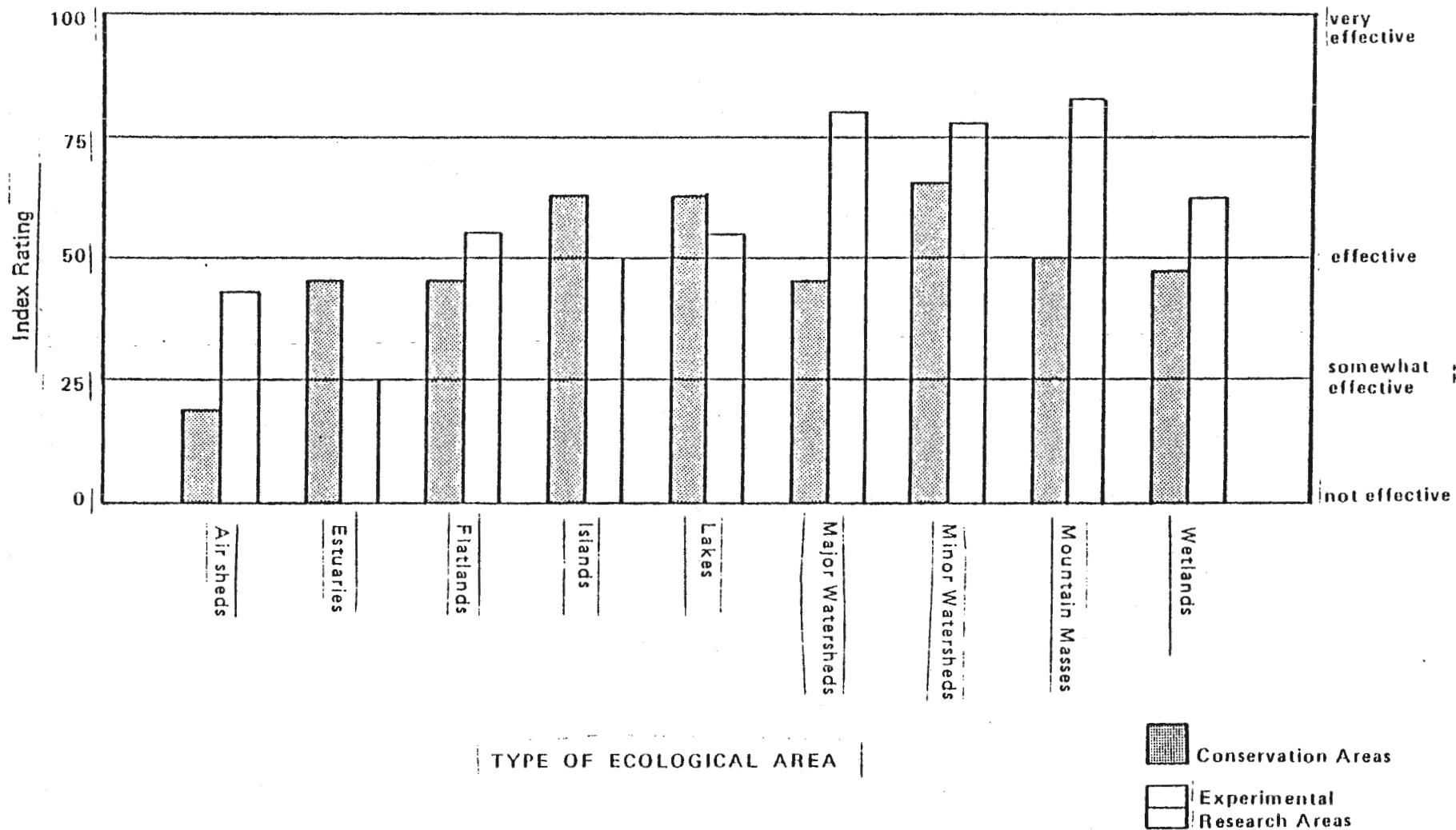
fore the most potentially threatened--were, in order of decreasing ratings: Everglades, Glacier, Sequoia, Rocky Mountain, Yellowstone, and Great Smoky Mountains. These reserves are particularly affected by urbanization and visitor-related impacts. The lowest-rated reserves, in order of decreasing ratings were: Isle Royale, Virgin Islands, Konza Prairie, Noatak, and the Aleutian Islands. All of these are in remote areas and support low to very low levels of visitation. The rating values for all conservation areas are summarized in Appendix Table 4.

We asked respondents to evaluate the effectiveness of the reserves in providing long-term protection of ecologically significant units of the earth's surface, and in protecting particular groups of plants and animals. The results are depicted in Figures 8 and 9.

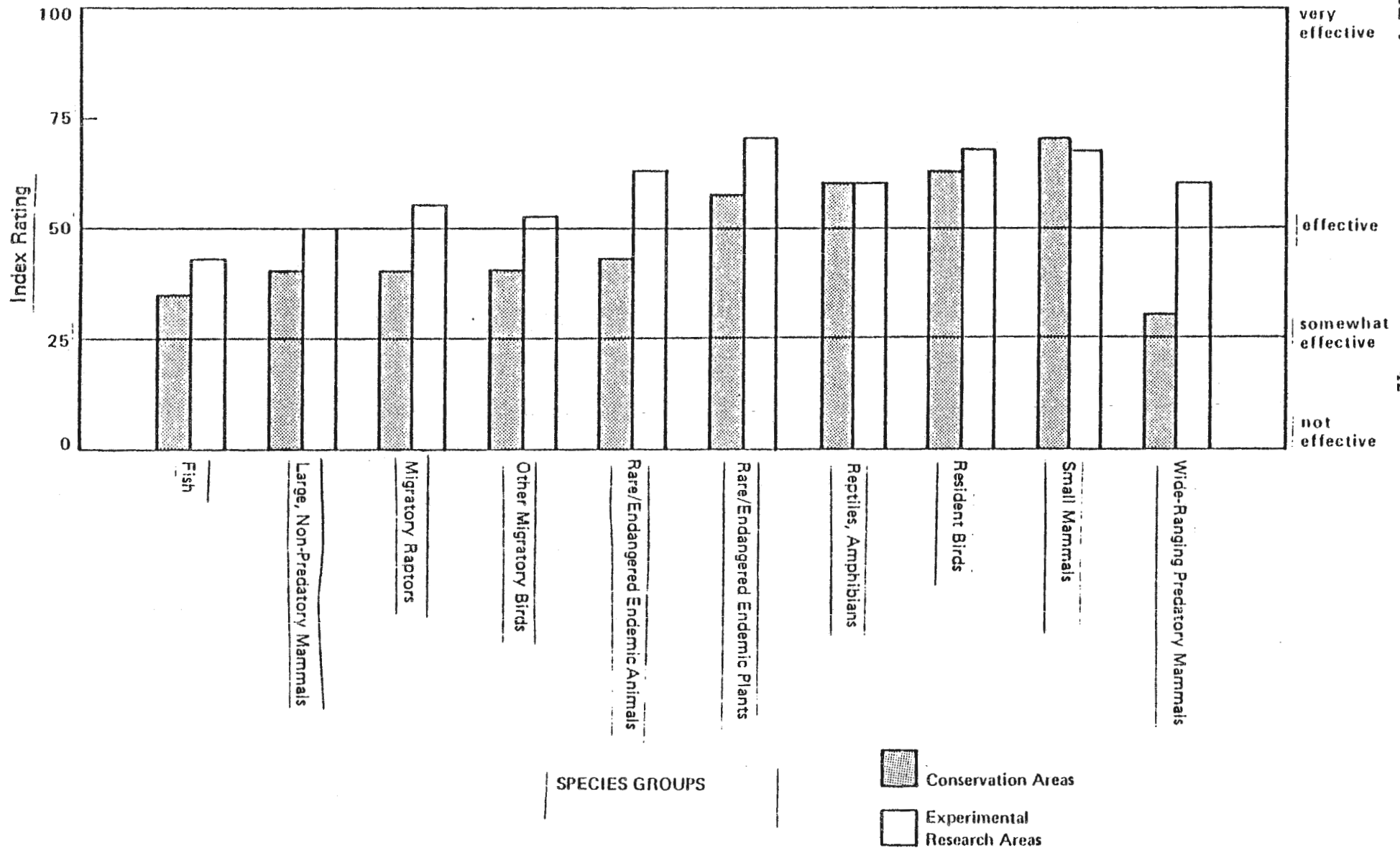
Most of the resources surveyed were viewed as effectively protected in the reserves. As expected, ratings tended to be highest for ecological units which are frequently included completely within the reserves, such as watersheds, mountain masses, lakes, and islands. Because most of the experimental areas were established to protect watersheds for experimental use, it is not surprising that these units received very high ratings for this group. Large-scale units, such as airsheds and estuaries, which typically extend well beyond reserve boundaries, received lower ratings. For biological resources, effectiveness ratings were higher for resident than for migratory wildlife, and higher for small than large animals, as expected. Protection was considered generally effective for animals. Fish--increasingly affected by acid precipitation, competition from exotics, and water pollution--were given the lowest rating in the experimental areas, and second only to wide-ranging mammalian predators in the conservation areas.

FIGURE 8

Index Ratings of U.S. Biosphere Reserves for Effectiveness in Conserving Ecologically Significant Areas



Index Ratings of U.S. Biosphere Reserves for Effectiveness in Conserving Species Groups



The respondents' perception of threats and the degree to which their reserve's scientific activities are focused on addressing them appear to be associated with their views as to the effectiveness of the reserves as conservation units. The experimental area respondents rated their reserves as considerably more effective in conservation than the respondents from conservation areas. This occurred for all ecological units except for estuaries, islands, and lakes, and for all biological groups except small mammals. Even airsheds and wide-ranging predatory mammals were considered more effectively conserved in the experimental areas! Because their research often deals substantially with threats, conservation area respondents are probably more keenly aware of anthropogenic influences which impinge on conservation effectiveness, and thus may be more inclined to assign lower ratings. However, in view of the inadequate level of documentation for most threats, it is impossible to determine from the survey whether the low ratings for the conservation areas reflect actual conditions or merely a heightened sensitivity to potential problems.

Regardless of the reasons for the discrepant results, it is clear that improved guideposts for evaluating the effectiveness of protected areas in assuring long-term conservation at the ecosystem, species, and population levels are urgently needed to provide a basis for management.

Professional Training

Professional training is an important function of nearly all U.S. biosphere reserves. The amount of activity is considerable, and occurs about equally in conservation and experimental areas. Of the 36 biosphere reserves, 26 are being used in varying degrees for undergraduate, and 30 for graduate, instruction. Reserves located near major universities, such as the Central Plains, Great Smoky Mountains, Coweeta, and Everglades Reserves, are used extensively in conjunction

with regular academic curricula. Others, such as the Luquillo Reserve, provide specialized instruction for visiting scientists and resource managers. Twenty of the reserves are sites for training programs to improve the scientific and resource management capabilities within administering government agencies, and three are planning to implement such programs. Sixteen support professional workshops, conferences, and symposia on a regular or periodic basis, and four more are planning to initiate such activities in the future.

Bilateral activities with other nations are poorly represented in the professional training programs of U.S. reserves. Only five sites: Coweeta, Hubbard Brook, Jornada, Haleakala and Olympic, report ongoing training programs involving other nations. The Luquillo Biosphere Reserve is widely recognized as an important center for training in tropical forestry, and has provided training in the past and plans to do so in the future. Four additional reserves--Big Bend, Isle Royale, Beaver Creek, Coram, and H.J. Andrews--anticipate future initiation of bilateral cooperative activities involving Mexico, Canada, and the USSR, in conjunction with broader programs of scientific cooperation.

Public Communication

Biosphere Reserves can play an important role in fostering public awareness of environmental problems and the role of science in addressing them. They can also help promote public recognition and support of MAB and the effective use of biosphere reserves as focal points for domestic and global cooperation to assure sustained conservation of biological resources.

The biosphere reserves in the United States are major centers for public communication. In many of the experimental areas, considerable communication focuses on the reserve's scientific and management programs, and how they are contributing to improved management practices to reduce adverse environmental impacts and

increase the productivity of managed ecosystems. Some activities are of an extension service nature, and oriented toward meeting the needs of foresters, cattlemen, farmers, soil conservationists, school groups, and other special groups. The numbers of visitors to these reserves is not large, and the multi-faceted public communication programs characteristic of most of the conservation areas are generally not available to them. However, our survey respondents indicated that although only about four experimental reserves in ten discuss MAB, these visitors are nevertheless, about four times as likely to find out about MAB and its concerns than visitors to the conservation areas.

Most of the conservation areas are national parks and monuments, and use a wide variety of media, facilities, and activities in public communication. In 1980, these areas received 27 million visitors, an immense population which is largely uninformed about MAB and its concerns.

Only 10% of the conservation areas provide public communication on MAB (38% for experimental areas). About 30% of these reserves address global environmental problems to some degree (about the same as for experimental areas); 65% discuss regional or national problems (vs 44% for experimental areas), 70% communicate information about science activities in the reserve (vs 63%), and 95% provide traditional interpretation of the reserve's natural history (vs 69%). Four reserves--Fraser, San Dimas, Stanislaus-Tuolumne and the Virginia Coast Reserve--report no public communication activities or facilities.

These data suggest that major opportunities are being missed to communicate information about interactions between human activities and natural ecosystems; and to link activities in the reserve with problems of regional, national, and global importance. The facilities and capabilities are already in place in most of the conservation, and many of the experimental, areas to take advantage of these

opportunities. For example, 75% of the conservation areas display a bronze biosphere reserve dedication plaque, but--as only 10% provide communication on MAB--the plaque probably generates more confusion than enlightenment. Ninety percent provide instruction to local school groups, 85% conduct ranger walks and talks, 85% have visitor centers providing literature distribution and sales as well as audiovisual presentations (55% exhibit the designation certificate in a visitor center, but again presumably without explanation); 65% provide trail-side exhibits and 25% provide exhibits and displays in a visitor center; and finally, 35% give lectures from time to time on man-biosphere interrelationships.

Most respondents expressed reservations about the effectiveness of their public communication program in conveying information about MAB biosphere reserves, and interrelationships between human activities and the biosphere. About 70% of the conservation and 77% of experimental area respondents rated the reserves progress as less than effective in the areas. Only 7 reserves rated their program as effective and only 2--Isle Royale and Yellowstone--as very effective. A surprising 97% of the respondents felt that guidance from MAB would be of potential or definite value.

A recent US-MAB workshop on public communication in biosphere reserves revealed that reserve personnel are often uninformed about MAB, biosphere reserves, and their role in dealing with national and global problems. A better informed reserve staff was viewed as key to more effective public communication. The workshop produced a set of guidelines, in question-and-answer format, to help reserve administrators develop public communication programs, and reached agreement on a number of recommendations, some with potential applicability internationally. A few of these are:

- *Increase training and dissemination of information to biosphere reserve personnel through visits to the reserves by MAB personnel.

- *Provide for wide dissemination of the public communication guidelines to the biosphere reserve network.
- *Develop an illustrated brochure describing the purpose and accomplishments of MAB's biosphere reserves project for distribution to the public.
- *Improve recognition by identifying the site's biosphere reserve status on all entrance signs; provide interpretation of this status wherever the dedication plaque or designation certificate is displayed; and briefly explain the significance of biosphere reserve status in orientation materials provided to visitors.
- *Edit the UNESCO-MAB slide tape on Project 8 to improve suitability for general audiences, and provide an opportunity to include material on the particular reserve in the presentation.
- *Develop travelling and duplicatable exhibits on global, national, and regional environmental problems and the role of science (and MAB) in addressing them, for use in the reserves.
- *Utilize national public interest groups, as well as local organizations, to disseminate information on MAB Project 8 and its activities.
- *Identify biosphere reserve status in publications relating to the reserve, and assure keyword reference.

Policies and Plans Relating to Biosphere Reserves

In the United States, the biosphere reserve designation is applied to legally protected sites, and has no legal protection in its own right. The fact that biosphere reserve status entails voluntary rather than legal obligations has been a positive factor in obtaining the initial support of administrators for designation. In most cases, the existing legal controls applicable to protected natural areas, particularly those in Federal ownership, are adequate to assure that the purposes of the biosphere reserve are fulfilled, provided administrators

make a reasonable effort to do so through development of policies and plans in accordance with their existing legal authorizations.

To determine whether such a reasonable effort is being made, we asked survey respondents to indicate whether policies and plans have been developed specifically for biosphere reserves in the areas of research, resource management, training, visitor use, public communication, and conservation of gene pools. The results indicated that the biosphere reserve designation is having a much greater influence in experimental than in conservation areas. The percentage of the reserves having policies relating to the reserve activities ranged between 63% and 81% for the experimental areas for all activities except conservation of gene pools (44%). Comparable figures for the conservation areas ranged between 0 and 10%. Administrators of experimental areas were also more likely to have developed plans reflecting biosphere reserve status, although the differences here were somewhat less. Reserve-specific guidance was most likely to be provided for resource management (81% of experimental and 40% of conservation areas), and research (69% and 40%), and substantially less likely for visitor use (50% and 20%), public communication (38% and 25%), and conservation of gene pools (31% and 20%).

The greater recognition of biosphere reserve status in the plans and policies of experimental area administrators may be due to the similarity between the management objectives for these areas and the purposes of biosphere reserves, particularly in research, demonstration, and training. Most of the experimental areas are research subunits of large production-oriented forests and rangelands, and biosphere reserve status strongly reinforces a pre-existing mission. Thus, the designation was presumably understood, accepted, and brought to bear on planning and policy making. Application of the biosphere reserve designation to the entire area was, in most cases, logical, as the entire area was used in a manner promoting the purpose of the reserve.

On the other hand, applying the biosphere reserve designation to entire units of the National Park System may have contributed to the present lack of influence the designation presently has on bureau plans and policies. The mission of the national parks is a dual one of conservation and public use, the latter receiving a much larger share of the bureau's budget and personnel allocations. When most of the reserves were designated in 1976, research and resource management activities played a relatively small role in park operations and were oriented primarily to meeting the immediate or short-term needs of management. A new designation, emphasizing these activities on a long-term basis over the entire park, did not reflect the prevailing management priorities in most of the designated areas. A recent conference on public communication in biosphere reserves revealed major misconceptions about the significance of biosphere reserve status existence in this Bureau today. A widely held view is that the designation merely records the global significance of some of the nation's finest national parks. Viewed in this context biosphere reserve status is unlikely to have much impact on policies and plans. It is possible that designation of alternative boundaries for the reserve involving less than the entire park, or perhaps areas inside and outside the park, might have improved the impact of the designation by redirecting the geographic focus of attention.

Whatever the causes, biosphere reserve status itself does not seem to determine program activities, and the management identity of the biosphere reserves in the United States appears to be determined primarily by agency missions.

SOME FUTURE DIRECTIONS

Our experience with the Udvardy system of biogeographic classification (Udvardy 1974) has been generally favorable, particularly when used in conjunction with the selection of a single reserve or reserve cluster within a large geographic

area. However, the boundaries of the classification units do not always precisely reflect the variations in climate, substrate, physiography, and vegetation which, are the most influential in controlling ecosystem structure and function at the regional level. For this reason, systematic review of the ecosystems of a particular biogeographic province for the purpose of biosphere reserve selection often requires adjustment of the province boundaries to fit the present state of knowledge regarding these ecosystem controls.

Although the Udvardy system provides a reasonable basis for biosphere reserve selection in terrestrial areas, we believe that opportunities for refinement should be pursued. Because of its greater degree of biogeographic subdivision and growing use by land management agencies, the recent classification system for ecoregions, developed by Bailey (1980), shows considerable promise as a straightforward procedure for defining and mapping major ecosystem on the basis of a synthesis of current knowledge. However, we believe that any revision of the system now in use should await the results of intensive on-going interagency texting of this and other systems.

More urgent attention needs to be given to the matter of biogeographic classification in coastal regions as the Udvardy system is not suitable for use in these areas. To develop a basis for coastal biosphere reserve selection in the United States and its territories, the US-MAB Directorate on Biosphere Reserves convened an expert panel in 1980, under the chairmanship of G. Carleton Ray. Major tasks included developing a working definition and classification system for use in selecting reserves in the coastal zone. The panel agreed to define the coastal zone as having a terrestrial boundary "defined by (a) the inland extent of astronomical tidal influence or (b) the inland limit of penetration of marine aerosols within the atmospheric boundary layer and including both salts and

marine aerosols, whichever is greater" and a seaward limit "defined by (a) the outer extent of the continental shelf (approximately 200m depth) or (b) the limit of U.S. territorial waters, whichever is greater." This definition includes onshore, nearshore, and oceanic ecosystems controlled by maritime and marine influences. An easy to use two-dimensional classification system was agreed upon which identifies twelve coastal regions based on terrestrial-nearshore and oceanic characteristics and 17 widely recognized ecosystem types based on abiotic and biotic characteristics, which are potentially represented within the coastal regions. The classification system, which is similar in general structure to others developed for conservation purposes (Ray, 1975; Cowardin and others, 1979), is now being tested on an experimental basis in selection of biosphere reserves in the Carolinian-South Atlantic Coastal Region.

Although the lands and waters within the coastal zone are included in nine biosphere reserves, the selection criteria for most of these areas were applied primarily to terrestrial resources. For this reason, most of the U.S. coastline will require scientific review to determine the most qualified coastal areas for nomination as biosphere reserves under the 1974 UNESCO criteria.

Selection Criteria

The UNESCO-UNEP Task Force which developed the 1974 criteria for selection of biosphere reserves recommended that the conservation mission of the biosphere reserve be focused at the ecosystem, rather the species level. Sites illustrating the maximum representation of the ecosystems of a particular biome, minimal evidence of human manipulation, and a high degree of effectiveness in conserving the diversity of life forms within the reserve are to be favored. The presence of unique features, such as unusual numbers of rare species, are regarded as secondary considerations, except in instances where unique areas can be justified as biosphere reserves on the basis of extraordinary research potential or the value of their genetic material. Of particular importance was the task force's recognition that a single reserve may be inadequate to protect a representative diversity of the natural ecosystems of a particular biogeographic province and that natural ecological variation should dictate the number of biosphere reserves required.

Our recent experience in the United States suggests that, when a good level of ecological information exists, the need to select a relatively large number of sites to obtain a representative diversity of ecosystems will be obvious from the start of the selection process. For this reason, new US-MAB guidelines encourage the selection of biosphere reserves consisting of multiple sites, and specifically allow a number of such reserves, normally not more than four, to be established within each province. US-MAB's recent nomination of the 12-site Big Thicket National Preserve in east Texas exemplifies this trend.

The multiple site biosphere reserve, linking individually qualified ecosystem units under the same or different administration within a single biosphere reserve designation, helps assure a level of ecosystem representation not normally possible with single site reserves in the classical tradition, or though the cluster concept--established at the initiation of the U.S. network--whereby separately designated conservation areas and experimental areas under different administrators are paired within the same province.

As stated previously, the classical biosphere reserve has been difficult to establish in the United States because of policies of administrators which limit the availability of large core zones or which preclude the conduct of experimental research. The cluster concept was a reaction to this limitation, and attempted to alleviate the problem by providing for large-scale conservation and experimental manipulation in geographically separate but ecologically similar areas (I.U.C.N. 1979; Johnson, W.C., and others, 1977). It has enabled the incorporation of experimental research areas with long histories of monitoring and research into the network, thereby fulfilling a major purpose of the reserves in developing improved methods for sustaining the productivity of natural ecosystems for human material and economic benefit.

By providing for much greater ecosystem representation, the multiple-site concept further strengthens the U.S. network, especially in conservation. The great majority of the sites in such reserves will be minimally disturbed ecosystems, sufficiently expansive to facilitate ecosystem-level research. Many of the sites are expected to be administered by non-Federal governmental agencies or private institutions. Some will have a substantial history of research in part of the protected area, but many will illustrate only a potential for such work. This should not be viewed as a major limitation, as we believe it is important to

designate qualifying areas while the opportunity to do so remains available. It is also worth noting that new U.S. guidelines allow for periodic review of biosphere reserve boundaries, and provide for boundary adjustments, and the addition of sites under the multiple-site concept, as required to fulfill the purposes of the reserves. Unique areas, degraded landscapes especially suitable for restoration research, traditional human use areas, and other sites of exceptional research and educational value could be considered in such reviews for integration into the larger reserves.

Although it is difficult to predict the ultimate size of the U.S. network, it is clear that protection of a representative diversity of major ecosystems will require designation of several reserves in most, if not all, selection areas. In many cases, the individual reserves will themselves consist of two or more sites. A not unreasonable average of three reserves per biogeographic province and one per coastal region would yield a total U.S. network of 72 units, or about twice the size of the present system.

Selection Procedures

The US-MAB Directorate on Biosphere Reserves has developed new guidelines for selection of biosphere reserves (Fernald, E.A., and others, 1981; Ray, G.C., and others, 1981), which provide a systematic approach for identifying candidate sites, summarizing relevant information, evaluating sites relative to UNESCO criteria and recommending nominations.

The cornerstone of the procedure is an ad hoc multidisciplinary panel of scientists and resource managers possessing preeminent knowledge of the ecosystems of a particular biogeographic province. The panel normally consists of four to seven members, representing land managing agencies, universities, and other institutions, as appropriate, to develop balanced perspectives on the

qualifications of candidate sites. The panel has considerable flexibility in identifying the factors to be used in describing and comparing the ecological features and conditions of candidate sites in a province, as well as the format for displaying this information. However, once these factors have been agreed upon, a disciplined procedure assures a high degree of objectivity and consistency in rating and selecting sites. The panel uses its discretion in determining how the identified factors will be considered in evaluating candidate sites against UNESCO criteria; it also has considerable latitude in adjusting the boundaries of the biogeographic province, and in subdividing the province into ecological regions for selection purposes. Specific guidance for carrying out these functions is not provided. However, our limited experience in testing the new guidelines indicates that well-informed panels can readily reach agreement on the basic framework for selection.

In identifying sites for evaluation, panels are urged to consider not only sites which appear to satisfy all UNESCO criteria, but also sites which, while obviously deficient in one or more respects, may provide opportunities for creating a fully adequate biosphere reserve through linkage with one or more other sites to form a multiple site reserve or reserve cluster.

Once the candidate sites have been identified and the framework for selection developed, panel members prepare descriptive factor summaries for those sites with which they are most familiar. These summaries involve the numerical scoring of certain factors based on the quality of the factor, or alternatively, an indication of whether a particular factor is present or absent. The descriptive factor summaries, along with supplemental information and analysis, are then used by the panel to evaluate the sites relative to UNESCO criteria.

The procedure for evaluation involves the rating of each site, or group of sites, relative to five criteria, which are weighted according to their relative importance in selection. Representative diversity at the ecosystem level, a single criterion combining the two closely interrelated essential criteria established by UNESCO, is accorded the greatest importance (weighting factor 10), followed by effectiveness as a conservation unit (3), naturalness (3), education and research value (2), and uniqueness (2). A five-point rating system is used consistently to record the extent to which each site satisfies each criterion. The total site rating score is the sum of the products of the rating for each criterion and the weighting factor for the criterion. The maximum possible score is 100.

The procedure operates as follows. An initial meeting of the panel is held to reach agreement on the framework for selection. Following this meeting, individual panel members obtain information on candidate sites and prepare site descriptions, which are forwarded along with appropriate supporting information to other panel members. Based on this material, all panel members rate each site using a standard evaluation form. A second meeting is then held, at which the individual evaluations are discussed and an attempt made to arrive at a consensus on the ratings to be assigned to each site. If the panel cannot reach a consensus, the individual ratings are averaged. As a general rule, sites receiving the highest ratings are recommended for nomination. However, the ratings are intended to be used as an indication of site qualification, rather than the sole basis for nomination. Thus, sites satisfying one or more criteria to an exceptional degree may be given extra weight in evaluation. Similarly, a less well qualified site in an otherwise unrepresented ecosystem type may be favored over a better qualified site in a ecosystem type represented by several candidates.

Upon completion of the selection process, a report documenting the rationale for site selection and including all descriptive and evaluative materials is submitted, along with site nomination forms, to the US-MAB Directorate on Biosphere Reserves. The Directorate then reviews the report and recommends nominations to the U.S. National Committee for MAB, which obtains the site manager's concurrence and a statement of intent to pursue three general goals:

- *to encourage multidisciplinary scientific studies leading to improved understanding, management, and use of natural and managed ecosystems;
- *to coordinate systematic planning for scientific, educational, and resource management activities in the area;
- *to avoid undertaking or authorizing actions which would significantly impair the value of the reserve for research and educational purposes.

Once these assurances have been received, the Committee forwards the nomination to the International Coordinating Council for action on designation.

Based on the results of preliminary testing, the procedure seems to work well in the United States, where a sufficient level of ecological information is usually readily available to support comparative analysis of sites. Its application in situations where information gaps are large remains to be determined. However, the use of ad hoc expert Panels to develop nominations by consensus would seem to be of universal value in improving the objectivity of site selection.

Assuming the availability of adequate funding (about \$5,000 U.S. per selection area), the review of each of the 20 biogeographic provinces and 12 coastal regions in the United States, and substantial completion of the biosphere reserve network, should be possible by 1984.

Development of Scientific Capabilities

A major impediment to the effective use of biosphere reserves is a lack of a compendium of summarized information on each reserve's past and present scientific activities as well as its facilities, data management capabilities, and institutional interrelationships.

Such a basic reference is invaluable in orientation of the reserve's scientific and management personnel, and in encouraging interinstitutional cooperation and use of the reserve by outside scientists. It also can serve as a vehicle for soliciting the broad involvement of the scientific community and other institutions in assessing the adequacy of the reserve's data bases and activities, and in enabling the administrator to develop a cost effective program for meeting both long-term and short-term needs for information. Finally, by creating a permanent and comprehensive record of the history of scientific activity in the reserve, it helps assure that previous knowledge is brought to bear in the development and testing of scientific hypotheses, and that continuity of data bases is maintained.

In August, 1980, a prototype study was initiated in the Great Smoky Mountains Reserve, utilizing an existing consortium of federal land managing agencies and universities.

In the first phase of the study, an annotated bibliography for the reserve and its immediate vicinity was prepared. Using these references, a summary of the scope, methods, and importance of previous work on particular topics was developed and forwarded to authorities on the ecosystem of the region, who were requested to supply additional references and to revise the summaries as necessary. These individuals were also asked to recommend, from their disciplinary points of view, actions needed to make existing scientific programs

more effective in characterizing the structure and function of the reserve's ecosystems, and in enabling the administrator to detect and deal with adverse changes in a timely and cost effective manner.

Recommendations were synthesized and a revised report sent to selected reviewers who made substantive recommendations based on the earlier material. An interdisciplinary workshop was then scheduled, bringing together scientists, the reserve administrator, and other governmental agencies to identify and prioritize needed actions, with particular attention given to identifying opportunities for cooperation with other agencies and institutions.

The overall effort involved more than 90 scientists and provided a framework for developing a phased, balanced science program for the biosphere reserve. Because the assessment's format provides for easy updating, its value should continue indefinitely. We believe this approach provides a highly effective, and relatively inexpensive way to promote improved scientific and educational use of biosphere reserves, improved coordination at all levels, and more efficient expenditure of limited research funds. Similar assessments are scheduled during the next year in four additional reserves.

Genetic Resources Protection and Management

US-MAB, in association with various Federal agencies, is cosponsoring two major workshops dealing with genetic resources. The first of these, scheduled for November 1981, is intended to develop perspective on the problem of declining global genetic diversity. Specifically, it will bring together scientists, resource managers, and agency administrators to assess the causes and magnitude of the problem; its economic, social, ecological, and political ramifications for the U.S. and other countries; the status of institutional capabilities, and the effectiveness of existing U.S. policies in dealing with the problem. The workshop will also recommend

initiatives to promote domestic and international efforts to maintain biological diversity.

The second workshop, scheduled to be held in Washington, D.C. from August 9-13, 1982, is intended to provide new perspective on the potential for managing the genetics of biological resources, with principal emphasis on the world's temperate zones. It will address problems in managing wild animal and plant populations as protected areas become progressively more isolated due to changes in peripheral land use and human activities which interfere with historical patterns of gene flow. Topics will include species declines and extinctions, the founding of new populations, the merging of separated populations, and maintaining the natural diversity of populations and taxonomic units. The workshop will identify gaps in our knowledge, and develop recommendations for interim management practices that could be implemented immediately, as well as for future study to provide a basis for mitigating adverse conditions and trends known to be occurring or anticipated in protected areas. Finally, the workshop will explore possible avenues for multidisciplinary, multiinstitutional, and multinational cooperation in addressing problems of biological resources management in a world vastly different from the one in which many of the protected species evolved. Eminent authorities in basic sciences, including botany, zoology, biogeography, systematics, and genetics, as well as applied fields, including wildlife management, livestock and agricultural genetics, horticulture, and silviculture, will provide their perspectives to an audience of resource managers, policymakers, and representatives from interested organizations and foreign governments, with the objective of bringing relevant information from diverse fields to bear on more effective management of biological resources in a rapidly changing world. The proceedings will be published immediately following the workshop to enable the greatest possible domestic and international transfer of information. Government and private sector responses to this

MAB initiative has been overwhelmingly positive. At this writing, four Federal agencies and 12 scientific and conservation organizations have agreed to cosponsor the workshop, and many are providing financial support. Complementary to these workshops will be a major MAB publication on the cultural significance of the world's natural genetic resources. Prepared by Margery Odfield and scheduled for publication in 1982, this work summarizes a wealth of practical information to support global efforts in genetic conservation.

CONCLUSIONS

The United States' network of biosphere reserves now contains 36 units, totalling 9 million hectares, and representing 16 of its 20 biogeographic provinces and 5 of its 12 coastal regions. At the present time, it is largely a Federal system, and contains many of the world's foremost national parks as well as some of its most significant sites for forest and range management research. All site administrators, whether Federal or private, have the capability and the intent to provide long-term protection. Scientific and educational activities in the reserves are extensive and increasing. Budgets and professional staff, while not adequate to meet expanding needs for management information, are growing, although this trend is most evident in the large conservation areas which are increasingly perceived to be jeopardized by numerous and severe anthropogenic threats. Several of the reserves are major centers for the study of the dynamics of natural and disturbed ecosystems, and four have been selected as sites in a multiyear pilot program to develop and evaluate integrated long-term ecological monitoring methodologies to characterize the causes and effects of ecosystem changes. By any standard, the network is making important contributions in conservation, scientific study, education, and training, and is furthering each of these major functions of biosphere reserves.

However, the results of a US-MAB survey completed in August 1981, when viewed along with other information on the biosphere reserve network, reveals deficiencies both individually and collectively in U.S. biosphere reserves:

- 1) Ecosystem representation. The biosphere reserve network does not yet contain a representative diversity of the nation's major ecosystems. Although most biogeographic provinces are represented in the network, existing reserves typically contain excellent examples of only a few ecosystems, and additional sites will be required in most provinces.

In coastal regions, deficiencies are greater, and only a few regions contain adequate ecosystem representation. A systematic review of each province and coastal region is required to assess ecological variability, and assure adequate representation of qualified sites. A reasonable estimate of the size of the network at completion is 72 sites, or about twice the existing number of reserves. Many of the reserves will consist of multiple sites under the same or different administration.

2) Effectiveness in conservation. An objective basis for assessing and comparing the effectiveness of biosphere reserves in conserving ecologically significant areas and taxonomic units is not available. In our survey, scientists in small experimental areas gave their biosphere reserves higher ratings than scientists in large conservation areas for effectiveness in conserving everything from wide-ranging predatory mammals to airsheds. These same respondents also considered their areas substantially less threatened by anthropogenic influences than did conservation area scientists. Although greater sensitivity to threats as a result of the research experience of the latter group may have been implicated, the results underscore the difficulty in determining how well the conservation mission of the biosphere reserves is being achieved. A major international initiative is needed to develop widely applicable methodologies in this critically important area.

3) Scientific Studies. Our survey revealed a very high variability in the perceived adequacy of the reserves' scientific data bases and activities to meet present and reasonably foreseeable scientific and management needs. Some reserves report many comprehensive activities while others indicated inadequate work in numerous areas.

Experimental areas were rated more adequate than the much larger conservation areas for 53 of the 82 activities surveyed, presumably a reflection of their generally longer histories of scientific study. Work in conservation areas focuses heavily on assessment of anthropogenic threats to natural ecosystems. Newer lines of integrated ecosystem research, such as nutrient cycling and ecosystem modelling, are poorly represented in these areas. Experimental areas tend to receive higher ratings in activities strongly related to assessing or improving the productivity of managed ecosystems, including most of the activities in which conservation areas show very poor representation. Although activities in the two groups of biosphere reserves are often complementary, they are not often integrated, even for reserves in the same biogeographic province. Where integration occurs, it tends to involve only one or two activities. Participation in seven domestic and international data banks is low. Most reserves participate in not more than two of these systems. None are involved in UNEP's Global Environmental Monitoring Programme. The survey suggests that most of the reserves are, for practical purposes, essentially autonomous study units.

A few of the study areas stand out as very poorly represented in the network as a whole: aquatic ecosystems, soil ecology in conservation areas, wildlife genetics, air pollution impact, and ethnobotany. Lack of information in these areas could impair the capability of the reserves to conserve genetic resources and habitats in the face of increasing human-caused threats. It is of interest to note that, of 793 reported known or suspected threats,--an average of 22 per reserve--only 271, or about 34%, are being addressed through scientific study. These results underscore the potential scale and diversity of new initiatives which may be required to provide for informed management in the future, as well as the exceptional opportunities for comparative study. To provide a framework for identifying these initiatives, the National Park Service has initiated

preparation of comprehensive compendia of information on scientific data bases, activities, and facilities for several of its biosphere reserve areas. These documents, in standard format, provide a basic reference for use by scientists and managers, and developing the most cost-effective long-term science program for its reserves.

4) Linkages

Michel Batisse (1981) has emphasized that the success of MAB may well depend on its ability to carry out projects which provide perspective on global or broad regional problems. He has stressed the desirability of developing regional networks of integrated pilot projects through which significant field studies with research, demonstration, and training components, provide the focus for cooperation at the domestic and international levels. As MAB's permanently protected sites for carrying out baseline and experimental study, the biosphere reserves should play a key role in this mission. However, a few noteworthy initiatives notwithstanding, the biosphere reserve network in the United States is not contributing very effectively in this area.

The problem seems to be due in part to the fact that the U.S. reserves do not have an independent management identity. Lacking their own legal protection, the biosphere reserve depends on the surrogate protection provided by the administrator's authorities, policies, and regulations. Their purposes thus tend to be achieved only to the extent they promote the administrator's mission. Because these missions are sectorial, the biosphere reserve programs tend to be directed toward limited objectives relating to a particular site, region, or area of inquiry

The number of linkages among the programs is disappointingly small. Our survey revealed that, of the 36 U.S. reserves, 23 are involved in on-going cooperative

monitoring or research with a regional institution, 14 in cooperative domestic undertakings with another biosphere reserve, and only three in international projects. Many of the linkages are focused on a single activity. Instances of integration of demonstration and training into these programs are substantially less than the number of reported projects.

Increasing use of biosphere reserves as focal points for domestic ecological research, as well as Federal efforts to develop and standardize resource inventory and ecological monitoring methodologies, should contribute to improved domestic coordination. International coordination of reserve activities will present a more formidable challenge.

A major strength of MAB lies in its ability to serve as a catalyst for building productive relationships between scientists in different nations possessing common research interests. It is at the level of the individual researcher where enthusiasm for such cooperation is likely to be greatest and the least encumbered by political constraints. We believe that the MAB Consortium, developed in the United States to award grants to domestic researchers for projects which simultaneously further the goals of participating MAB Projects (1,2,5, and 8) and governmental agencies, provides a useful institutional model for encouraging these professional relationships. In using this MAB institution to fund the U.S. side of projects which are also actively supported by governments or institutions in other countries, U.S. agencies are able to support high priority domestic research and at the same time obtain, at little or no cost, the benefit of the additional perspective generated from complementary work on a similar problem elsewhere. The participating nation receives the same benefit. The peer review process used in grant evaluation provides considerable assurances of the quality

and utility of the bilateral research efforts. The success of biosphere reserve linkages will depend on the extent to which they can be demonstrated to contribute to the missions of reserve administrators. Such projects as the US-Mexico range management and wildlife conservation research effort involving the Beaver Creek and LaMichilia Biosphere Reserves are providing the necessary evidence, but many more such projects are needed. Improvement in information flow among reserves, with emphasis on those in ecologically similar regions, and the development of institutional support for bilateral projects would seem to be appropriate areas of priority consideration for the Ecosystem Conservation Group.

BIBLIOGRAPHY

- Bailey, R.G. 1980. Description of the ecoregions of the United States. U.S. Department of Agriculture, Forest Service, Miscellaneous Publication No. 1391. 77pp.
- Batisse, M. 1981. MAB: a new scientific approach to environmental management and conservation. *Parks* 6(1): 7-11.
- Botkin, D.B. and others. 1977. Long-term ecological measurements: report of a conference. Woods Hole, Massachusetts. March 16-18, 1977. The National Science Foundation, Division of Environmental Biology, Washington, D.C. 26pp.
- Botkin, D.B. and others. 1978. A pilot program for long-term observation and study of ecosystems in the United States: report of a second conference on long-term ecological measurements. Woods Hole, Massachusetts. February 6-10, 1978. The National Science Foundation, Division of Environmental Biology, Washington, D.C. 27pp.
- Brown, Kenneth W. 1981. Pollutant monitoring in the Olympic National Park Biosphere Reserve. *Environmental Monitoring and Assessment* 1(1):37-47.
- Cowardin, L.M., Virginia Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Government Printing Office, Pub. No. 024-010-00524-6. Washington, D.C.
- Fernald, E.A.; T.V. Armentano; W.P. Gregg, Jr.; A. Radford; Rebecca Sharitz; and C. Wharton. 1981. Guidelines for identification, evaluation, and selection of biosphere reserves in the United States. United States Man and the Biosphere Program, Project 8 (Biosphere Reserves). National Park Service, Office of Science and Technology, Washington, D.C. 20240.
- Gregg, W.P., Jr. and I. Zube. (in prep.) MAB guidelines for public communication in biosphere reserves. A summary of the results of a workshop cosponsored by the US-MAB Directorates on Human Perceptions and Biosphere Reserves, Arlington, Virginia, July 14-15, 1981.
- International Union for Conservation of Nature and Natural Resources. 1974. Biotic provinces of the world. IUCN Occasional Paper No. 9. IUCN, Morges, Switzerland.
- International Union for Conservation of Nature and Natural Resources. 1979. The biosphere reserve and its relationship to other protected areas. IUCN, Morges, Switzerland.
- Johnson, W.C., J.S. Olson, and D.E. Reichle. 1977. Management of experimental reserves and their relation to conservation reserves: the reserve cluster. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Hemstrom, M. and J.F. Franklin, eds. 1981. Successional research and environmental pollutant monitoring associated with biosphere reserves. Proceedings of the Second U.S.-U.S.S.R. Symposium on Biosphere Reserves, Everglades National Park, Florida. March 1980. U.S. Government Printing Office, Washington, D.C.
- Mack, Alison; W.P. Gregg, Jr.; Susan P. Bratton; and P.S. White. (in press). A survey of ecological inventory, monitoring and research in U.S. National Park Service Biosphere Reserves. Uplands Biological Laboratory, Great Smoky Mountains National Park, Gatlinburg, Tennessee.

BIBLIOGRAPHY - Continued

- National Park Service. 1980. State of the parks - 1980: a report to the Congress. National Park Service, Office of Science and Technology, Washington, D.C. 20240.
- Ray, G.; J.R. Clark; Nancy M. Foster; W.P. Gregg, Jr.; P.J. Godfrey; B.P. Hayden; S.P. Leatherman; W.E. Odum; and J.H. Sather. 1981. Interim guidelines for identification and selection of coastal biosphere reserves. A report to the US-MAB Directorate on Biosphere Reserves (MAB-8). National Park Service, Office of Science and Technology, Washington, D.C. 20240.
- Ray, G.C. 1975. A preliminary classification of coastal and marine environments. Occasional Paper No. 14. IUCN, Morges, Switzerland.
- Risser, P.G., and Kathy D. Cornelison. 1979. Man and the Biosphere: U.S. Information Synthesis Project, MAB-8 Biosphere Reserves. Oklahoma Biological Survey, Norman, Oklahoma. 109pp.
- Udvardy, M.D.F. 1975. A classification of the biogeographical provinces of the world. IUCN Occasional Paper No. 18. IUCN, Morges, Switzerland.
- UNESCO. 1973. Programme on Man and the Biosphere (MAB), Expert Panel on Project 8: onservation of natural areas and the genetic material they contain. Morges, Switzerland. September 25-27, 1973. UNESCO Report Series No. 12. UNESCO, Paris.
- UNESCO. 1974. Programme on Man and the Biosphere (MAB), Task Force on: Criteria and guidelines for the choice and establishment of biosphere reserves. Paris, France. May 22-24, 1974. UNESCO Report No. 22. UNESCO, Paris.
- U.S. National Committee for MAB. 1976. Report of the first regional workshop on research and monitoring in U.S. biosphere reserves. Gatlinburg, Tennessee. November 3-5, 1976. Unpublished ms. U.S. National Committee for MAB, Department of State, Washington, D.C. 20520. 3pp.
- U.S. National Committee for MAB. 1977a. U.S. Man and the Biosphere: Pacific northwest biosphere reserve workshop. Corvallis, Oregon. May 12-14, 1977. Unpublished ms. U.S. National Committee for MAB, Department of State, Washington, D.C. 20520. 22pp.
- U.S. National Committee for MAB. 1977b. Southwest biosphere reserves workshop. Tucson, Arizona. March 30-April 2, 1977. Unpublished ms. U.S. National Committee for MAB, Department of State, Washington, D.C. 20520. 9pp.
- U.S. National Committee for MAB. 1977c. Biosphere reserve project: Rocky Mountain biosphere reserve workshop. Boulder, Colorado. November 16-18, 1977. Unpublished ms. U.S. National Committee for MAB, Department of State, Washington, D.C. 20520. 29pp.
- U.S. National Committee for MAB. 1978. Pacific southwest biosphere reserve workshop. Santa Barbara, California. Unpublished ms. U.S. National Committee for MAB, Department of State, Washington, D.C. 20520.
- U.S. National Committee for MAB. 1979. Long-term ecological monitoring in biosphere reserves. U.S. National Committee for MAB, Department of State, Washington, D.C. 20520. 31pp.

BIBLIOGRAPHY - Continued

Wiersma, G.B., K.W. Brown, and A.B. Crockett. 1978. Development of a pollutant monitoring system for biosphere reserves and results of the Great Smoky Mountains pilot study. Pp. 451-456. In Proceedings of the Fourth Conference on Sensing of Environmental Pollutants. American Chemical Society, Washington, D.C.

SUMMARY OF RESULTS OF A SURVEY OF BIOSPHERE RESERVES
IN THE UNITED STATES

August 1981

Table 1A. Index Ratings for Baseline Information Categories

Biosphere Reserve ¹	Categories										Composite index rating ²
	Aerial imagery/ photography	Aquatic eco- systems	Bibliography	Data storage and management	Disturbances	Fauna	Flora and vegetation	Geology and physiography	Macroclimate	Soils and sediment maps	
Aleutian Islands NWR (c)	25	25	25	0	19	42	55	62	19	0	32
Beaver Creek EW (e)	100	50	100	75	69	75	100	44	50	100	72
Big Bend NP (c)	25	25	0	50	25	33	35	88	50	25	39
Cascade Head EF (e)	100	29	100	75	62	92	75	44	56	75	61
Central Plains ER (e)	50	29	75	50	50	75	65	19	44	50	47
Channel Islands NP (c)	100	33	100	25	38	50	80	88	44	100	58
Coram EF (e)	75	21	75	100	67	25	65	25	31	75	44
Coweeta EF (e)	100	83	75	75	94	58	70	56	62	100	74
Denali NP (c)	50	17	75	50	62	50	40	62	38	25	43
Desert ER (e)	75	0	50	50	81	67	60	75	42	50	49
Everglades NP (c)	75	96	75	50	75	67	80	62	81	75	78
Fraser EF (e)	100	4	75	50	12	42	50	25	56	50	35
Glacier NP (c)	50	46	75	25	56	50	60	31	38	25	47
Great Smoky Mountains NP (c)	100	62	100	100	75	58	55	69	62	50	67
H. J. Andrews EF (e)	100	71	100	75	81	75	75	67	62	75	74

¹Predominant management emphasis indicated as (c) conservation or (e) experimental research.

²Composite rating = $\frac{\text{total points received for all activities} \times 100}{\text{total possible points}}$

Table 1A. Index Ratings for Baseline Information Categories (Continued)

Biosphere Reserve	Categories										
	Aerial imagery/ photography	Aquatic eco- systems	Bibliography	Data storage and management	Disturbances	Fauna	Flora and vegetation	Geology and physiography	Macroclimate	Soils and sediment maps	Composite index rating
Haleakala NP (c)	75	58	75	75	69	75	70	75	50	50	66
Hawaii Volcanoes NP (c)	75	17	50	50	50	50	50	94	24	25	42
Hubbard Brook EF (e)	100	75	100	75	50	58	65	38	88	50	66
Isle Royale NP (c)	75	38	75	25	75	67	75	44	44	0	54
Jornada ER (e)	50	17	100	75	81	50	80	38	56	75	59
Konza Prairie RNA (c)	100	50	100	75	81	50	80	88	38	0	65
Luquillo EF (e)	100	54	100	75	88	92	90	75	50	25	73
Niwot Ridge (c)	75	46	75	50	25	75	90	58	100	100	66
Noatak NAR (c)	75	21	75	0	69	25	30	69	56	75	45
Olympic NP (c)	100	33	100	50	50	50	35	56	69	25	50
Organ Pipe Cactus NM (c)	100	46	50	50	25	50	30	50	56	25	44
Rocky Mountain NP (c)	100	46	100	50	62	58	40	50	69	25	55
San Dimas EF (e)	75	46	75	75	62	33	65	50	31	75	52
San Joaquin ER (e)	100	25	100	75	62	75	90	31	56	100	60
Sequoia-Kings Canyon NP (c)	50	8	100	50	56	42	50	31	44	0	38
Stanislaus-Tuolumne EF (e)	100	--	100	75	38	0	45	25	50	0	40
Three Sisters Wilderness (c)	100	25	75	25	44	50	50	56	38	50	45
University of Michigan Biological Station (c)	75	88	100	75	94	92	85	83	81	100	87
Virgin Islands NP (c)	75	33	50	50	25	25	20	75	38	25	38
Virginia Coast Reserve (c)	75	25	75	50	94	42	65	50	0	75	48
Yellowstone NP (c)	100	38	50	100	75	50	50	94	50	25	59

Table 1A. Index Ratings for Baseline Information Categories (Continued)

	Categories										
	Aerial imagery/ photography	Aquatic eco- systems	Bibliography	Data storage and management	Disturbances	Fauna	Flora and vegetation	Geology and physiography	Macroclimate	Soils and sediment maps	Composite index rating
Average index ratings:											
Conservation areas	75	40	72	50	59	51	54	65	48	37	53
Experimental areas	88	38	86	67	60	59	71	45	54	69	64
All biosphere reserves	80	39	77	57	59	54	61	57	50	49	57

Table 1B. Index Ratings for Activities Within Baseline Information Categories

<u>Category and Activity</u>	<u>All Reserves</u>	<u>Index Ratings Conservation Areas</u>	<u>Experimental Areas</u>
Aquatic Ecosystems			
Aquatic organisms	42	48	35
Groundwater hydrology	26	25	28
Bottom morphology of aquatic features	34	35	32
Physical parameters	44	42	48
Surface hydrology	48	45	52
Water chemistry	39	45	32
Disturbances			
Human-caused disturbance history	68	65	72
Exotic species (incl. diseases)	44	45	42
Land use changes	72	70	75
Natural disturbance history	53	52	55
Fauna			
Abundance	56	52	60
Checklists and keys	64	60	68
Collections	45	42	48
Flora and Vegetation			
Checklists and keys	71	60	85
Collections	64	60	68
Maps	67	65	70
Productivity	45	30	65
Structure of vegetation	63	55	72

Table 13. Index Ratings for Activities Within Baseline Information Categories
(Continued)

<u>Category and Activity</u>	<u>All Reserves</u>	<u>Index Ratings</u>	
		<u>Conservation Areas</u>	<u>Experimental Areas</u>
Geologic Features			
Seismic activity	43	65	14
Surficial geology maps	66	75	55
Topographic maps	92	95	88
Unusual substrate chemistry	24	30	16
Macroclimate			
Air quality	38	45	30
Soil temperature and moisture	44	28	60
Weather data	77	65	90
Wet fall/dry fall chemistry	41	40	42

Key to Ratings

- 0 No baseline information is available.
- 25 Available information is outdated or very limited, and of very little utility in scientific and management applications.
- 50 Available information is incomplete, often variable in quality, and with scientific and management applicability only in highly specific areas.
- 75 Available information is somewhat incomplete, generally of good quality, and with scientific and management applicability in several areas.
- 100 Available information is comprehensive, of good-to-excellent quality, and with scientific and management applicability in many areas.

Table 2A. Index Ratings for Long-term Environmental Monitoring

	Categories					
	Aerial imagery	Water resources	Disturbances	Seismic activity	Macroclimate	Composite index rating ²
Biosphere Reserve ¹						
Aleutian Islands NWR (c)	25	25	42	100	31	36
Beaver Creek EW (e)	100	92	100	25	67	82
Big Bend NP (c)	50	31	50	25	50	42
Cascade Head EF (e)	75	44	75	--	56	58
Central Plains ER (e)	50	25	50	--	44	40
Channel Islands NP (c)	25	31	42	100	56	46
Coram EF (e)	--	50	50	--	75	57
Coweeta EF (e)	--	92	100	--	83	92
Denali NP (c)	25	25	58	100	50	46
Desert ER (e)	--	--	--	--	50	50
Everglades NP (c)	50	88	50	--	62	67
Fraser EF (e)	--	25	25	--	67	41
Glacier NP (c)	25	31	33	25	50	36
Great Smoky Mountains NP (c)	75	75	67	50	75	73
H. J. Andrews EF (e)	100	69	92	--	62	75
Haleakala NP (c)	50	--	50	75	50	41
Hawaii Volcanoes NP (c)	50	25	50	100	31	40

¹ Predominant management emphasis: (c) conservation or (e) experimental research.

² Composite rating: $\frac{\text{total points received} \times 100}{\text{total possible points}}$

Table 2A. Index Ratings for Long-term Environmental Monitoring (Continued)

	Categories					
	Aerial imagery	Water resources	Disturbances	Seismic activity	Macroclimate	Composite index rating
Biosphere Reserve						
Hubbard Brook EF (e)	100	81	58	--	88	79
Isle Royale NP (c)	50	38	25	--	38	35
Jornada ER (e)	50	33	92	--	75	65
Konza Prairie RNA (c)	75	94	75	--	81	84
Luquillo EF (e)	100	50	83	--	50	62
Niwot Ridge (c)	50	31	42	--	100	58
Noatak NAR (c)	50	44	42	50	38	42
Olympic NP (c)	75	25	25	25	69	40
Organ Pipe Cactus NM (c)	75	56	42	25	62	54
Rocky Mountain NP (c)	--	31	33	25	62	42
San Dimas EF (e)	75	75	67	50	75	71
San Joaquin ER (e)	25	--	100	--	75	79
Sequoia-Kings Canyon NP (c)	25	31	58	25	44	40
Stanislaus-Tuolumne EF (e)	25	25	25	25	25	25
Three Sisters Wilderness (c)	75	44	75	25	50	48
University of Michigan Biological Station (c)	50	62	100	--	75	75
Virgin Islands NP (c)	50	25	25	50	31	31
Virginia Coast Reserve (c)	75	69	92	--	75	78
Yellowstone NP (c)	75	62	67	100	50	63

Table 2A. Index Ratings for Long-term Environmental Monitoring (Continued)

	Categories				
	Aerial imagery	Water resources	Disturbances	Seismic activity	Macroclimate
Average index ratings:					Composite index rating
Conservation areas	51	46	51	67	53
Experimental areas	69	52	69	31	65
All biosphere reserves	58	49	58	59	58

Table 2B. Index Ratings for Activities Within Categories for Long-term Environmental Monitoring

Category and Activity	All Reserves	Index Ratings	
		Conservation Areas	Experimental Areas
Water Resources			
Groundwater level	40	42	35
Physical parameters	46	40	55
Surface hydrology/tides	55	50	60
Water chemistry	50	50	50
Disturbances			
Human-caused disturbances	60	50	72
Land use changes	64	60	75
Natural disturbances	57	45	70
Macroclimate			
Air quality	52	50	55
Soil temperature/moisture	45	35	58
Weather data	73	65	82
Wet fall/dry fall chemistry	67	62	72

Key to Ratings

- 25 Monitoring is severely inadequate to meet known or reasonably foreseeable information needs.
- 50 Monitoring is incomplete, but will partially meet known or reasonably foreseeable information needs.
- 75 Monitoring is somewhat incomplete, but will meet most known or reasonably foreseeable information needs.
- 100 Monitoring is comprehensive; will meet all known or reasonably foreseeable information needs.

Table 2A. Index Ratings for Long-term Environmental Monitoring (Continued)

	Categories					Composite index rating
	Aerial imagery	Water resources	Disturbances	Seismic activity	Macroclimate	
Average index ratings:						
Conservation areas	51	46	51	67	53	51
Experimental areas	69	52	69	31	65	61
All biosphere reserves	58	49	58	59	58	55

Table 2B. Index Ratings for Activities Within Categories for Long-term Environmental Monitoring

Category and Activity	All Reserves	Index Ratings	
		Conservation Areas	Experimental Areas
Water Resources			
Groundwater level	40	42	35
Physical parameters	46	40	55
Surface hydrology/tides	55	50	60
Water chemistry	50	50	50
Disturbances			
Human-caused disturbances	60	50	72
Land use changes	64	60	75
Natural disturbances	57	45	70
Macroclimate			
Air quality	52	50	55
Soil temperature/moisture	45	35	58
Weather data	73	65	82
Wet fall/dry fall chemistry	67	62	72

Key to Ratings

- 25 Monitoring is severely inadequate to meet known or reasonably foreseeable information needs.
- 50 Monitoring is incomplete, but will partially meet known or reasonably foreseeable information needs.
- 75 Monitoring is somewhat incomplete, but will meet most known or reasonably foreseeable information needs.
- 100 Monitoring is comprehensive; will meet all known or reasonably foreseeable information needs.

Table 3A. Index Ratings for Ecological Research Categories

	Categories			
	Vegetation and Ecosystem	Wildlife	Soil Ecology	Composite Index ² Rating
Biosphere Reserve ¹				
Aleutian Islands NWR (c)	30	47	25	38
Beaver Creek EW (e)	68	64	38	64
Big Bend NP (c)	28	28	25	28
Cascade Head EF (e)	41	53	33	46
Central Plains ER (e)	48	48	42	47
Channel Islands NP (c)	34	28	25	30
Coram EF (e)	53	38	75	53
Coweeta EF (e)	61	50	42	54
Denali NP (c)	28	27	25	27
Desert ER (e)	39	32	25	34
Everglades NP (c)	59	68	25	60
Fraser EF (e)	41	25	--	35
Glacier NP (c)	33	40	25	36
Great Smoky Mountains NP (c)	56	47	25	49
H. J. Andrews EF (e)	60	52	67	57
Haleakala NP (c)	40	40	25	38
Hawaii Volcanoes NP (c)	34	31	25	32
Hubbard Brook EF (e)	95	78	25	78

¹Predominant management emphasis: (c) conservation or (e) experimental
²Composite rating: $\frac{\text{total points received} \times 100}{\text{total possible points}}$ research

Table 3A. Index Ratings for Ecological Research Categories (Continued)

	Categories			
	Vegetation and Ecosystem	Wildlife	Soil Ecology	Composite Index Rating
<u>Biosphere Reserve</u>				
Isle Royale NP (c)	50	42	25	44
Jornada ER (e)	44	38	42	41
Konza Prairie RNA (c)	35	38	33	36
Luquillo EF (e)	51	46	42	48
Niwot Ridge (c)	53	50	50	52
Noatak NAR (c)	27	25	25	26
Olympic NP (c)	34	36	25	34
Organ Pipe Cactus NM (c)	38	34	25	34
Rocky Mountain NP (c)	32	29	25	30
San Dimas EF (e)	51	38	50	45
San Joaquin ER (e)	50	56	50	53
Sequoia-Kings Canyon NP (c)	38	27	25	32
Stanislaus-Tuolumne EF (e)	25	25	25	25
Three Sisters Wilderness (c)	36	46	50	42
University of Michigan Biological Station (c)	47	67	75	58
Virgin Islands NP (c)	25	25	25	25
Virginia Coast Reserve (c)	35	28	25	31
Yellowstone NP (c)	39	48	25	42
<u>Average index ratings:</u>				
Conservation areas	36	36	28	36
Experimental areas	51	46	44	48
All biosphere reserves	43	42	35	42

Table 3B. Index Ratings for Activities Within Ecological Research Categories

Category and Activity ³	Index Ratings				
	All Reserves	Conservation Areas (No. ⁴)	Experimental Areas (No. ⁴)		
Vegetation and Ecosystem					
Acid precipitation impact (30)	41	40	8	43	5
Air pollution impact (33)	36	35	7	38	5
Aquatic vegetation (30)	34	30	4	40	5
Carbon cycling (33)	39	30	2	53	6
Desertification (5)	36	25	0	43	2
Ecosystem modelling (35)	43	33	4	55	9
Energy flow studies (33)	35	30	3	48	4
Ethnobotanical studies (27)	29	30	1	25	1
Exotic species control (28)	39	40	8	35	1
Fire ecology (28)	50	50	5	50	4
Grazing impact (22)	49	45	3	55	5
Mining reclamation (8)	25	25	0	25	0
Nutrient cycling (35)	41	30	4	55	8
Productivity studies (35)	46	33	5	70	13
Rare/endangered plant populations (30)	44	48	11	38	5
Silvicultural studies (23)	50	33	1	65	8
Succession studies (34)	54	48	14	65	11
Tropical forest restoration/management (5)	60	50	3	100	1
Visitor impact (23)	43	45	7	38	4
Wildlife					
Ethnozoological studies (25)	32	33	3	28	0
Exotic species control (28)	38	43	8	28	1
Genetic resource management (25)	29	30	6	25	1
Impacts of grazing animals on wildlife (20)	38	33	2	45	1
Impacts of regional land use changes (28)	33	30	6	40	3
Population dynamics:					
Amphibians (29)	36	30	2	45	4
Aquatic invertebrates (34)	40	35	6	48	5
Aquatic mammals (22)	35	33	6	40	0
Fishes (35)	45	45	7	45	5
Insects/crustaceans (35)	42	35	7	52	6
Large mammals (33)	49	45	14	55	3
Migratory birds (34)	42	38	6	48	5
Rare/endangered species (27)	44	45	11	40	2
Reptiles (29)	39	35	3	45	4
Resident birds (36)	52	45	11	60	6
Small mammals (36)	47	35	6	60	6
Visitor impact studies (25)	34	35	3	32	2

³Number of reserves rating the research activity are indicated in parentheses.

⁴Number of reserves reporting ongoing studies, ex 20 conservation areas and 16 experimental areas.

Table 3B. Index Ratings for Activities Within Ecological Research Categories
(Continued)

Category and Activity	Index Ratings				
	All Reserves	Conservation Areas (No.)		Experimental Areas (No.)	
Soil Ecology					
Macrofauna studies (33)	35	30	2	42	2
Microflora/microfauna studies (35)	36	28	2	50	6
Mycorrhizal associations (34)	32	28	1	38	5

Key to Ratings

25	Inadequate
50	Somewhat adequate
75	Adequate
100	Fully comprehensive

Table 4. Rating of Biosphere Reserves for Categories of Anthropogenic Threats

Biosphere Reserve	Threat Categories:			Phys. Removal of Resources	Phys. Impact of Visitor Activities	Water Poll. & Hydrology	Mean Rating ¹ All Categories
	Air Pollution	Exotic Encroachment	Operations				
Aleutian Is. NWR	0.3	1.0	0.2	1.3	1.1	1.1	0.8
Big Bend NP	1.3	2.2	2.6	2.1	1.9	1.3	1.9
Channel Is. NP	1.4	3.0	1.4	2.1	2.0	1.5	1.9
Denali NP	1.0	0.8	2.7	1.7	3.0	1.7	1.8
Everglades NP	3.1	3.0	3.6	2.9	2.6	2.5	3.0
Glacier NP	3.0	3.5	2.8	2.4	2.9	2.7	2.9
Great Smoky Mtns. NP	2.4	2.2	1.9	1.8	3.0	1.0	2.0
Haleakala NP	3.0	2.5	0.2	0.9	0.6	0.2	1.2
Hawaii Volcanoes NP	4.0	3.0	1.7	0.9	1.3	0.4	1.9
Isle Royale NP	1.7	2.0	0.7	0.4	1.4	0.9	1.2
Konza Prairie RNA	3.0	1.5	1.4	0	0	0	1.0
Noatak NAR	0.3	0	1.4	1.8	2.1	0	0.9
Olympic NP	1.3	2.0	1.8	1.4	2.1	1.0	1.6
Organ Pipe Cactus NM	1.5	2.2	0.9	2.0	1.4	1.0	1.5
Rocky Mtn. NP	3.4	3.0	2.2	2.4	2.9	0.8	2.4
Sequola-Kings Canyon NP	1.9	3.5	3.6	2.3	3.0	0.8	2.5
Univ. of Michigan Biological Sta.	1.0	0	1.2	0.7	0.6	0	0.6
Virgin Is. NP	1.7	1.5	0.9	1.0	0.9	0.7	1.1
Va. Coast Reserve	0	2.8	1.6	1.7	1.7	0	1.3
Yellowstone NP	1.3	3.0	1.7	2.1	2.3	2.7	2.2
Mean, all sites:	1.8	2.1	1.7	1.6	1.8	1.0	

¹Rating values calculated as total point score for threats in category/total number of threats in category