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CHAPTER 28

Putting the Biosphere Reserve Concept into Practice: the United States Experience

William P. Gregg, Jr. and Monica M. Goigel

Abstract

The biosphere reserve system in the United States includes 36 units representing 16 biogeographic provinces and five coastal regions. Its administrative structure and the selection procedures for US biosphere reserves are discussed. The status of monitoring, research, demonstration, training, and public communication is evaluated, and opportunities for improving the impact of the biosphere reserve system 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.

Résumé

Le système des réserves de la biosphère aux Etats-Unis compte 36 unités qui représentent 16 provinces biogéographiques et cinq régions côtières. Leur structure administrative et les procédures du choix des réserves de la biosphère sont discutées. Les progrès de la surveillance continue, de la recherche, de la démonstration, de la formation et de l'information du public sont évalués et les possibilités d'amélioration de l'impact du système de réserves de la biosphère sur les problèmes les plus significatifs de gestion des écosystèmes à l'échelle régionale et globale, sont explorées. L'accent est mis sur le besoin d'intégrer dans des biomes les recherches sur les écosystèmes et les activités qui leur sont reliées, ainsi que sur le développement de projets pilotes bilatéraux.

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CONDITIONS AND ACTIVITIES IN US BIOSPHERES RESERVES

BIOSPHERE reserve activities have formed a primary focus for United States participation in the Man and Biosphere (MAB) Programme, since the Programme's inception in 1971. The aim of the paper and accompanying appendix is to outline some of the problems and challenges that have been encountered in putting the biosphere reserve concept into practice in the United States and to report on some of the activities that are being promoted within the biosphere reserve network in our country.

As of mid-1981, the biosphere reserve network in the United States comprised 36 units.[1] In order to provide an indication of the degree to which these 36 biosphere reserves in the United States are fulfilling their purpose, US-MAB conducted a survey of reserve managers in mid-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 programmes and anthropogenic threats, and its effectiveness as a conservation unit.

Because the purpose of reserve administration is known to have a strong bearing on its use and management, it was decided to group the US reserves into two categories on the basis of predominant management emphasis, in analyzing the survey data. One group consisted of 22 sites managed primarily for ecosystem conservation, such as national parks and monuments, national wildlife refuges, and equivalent reserves. They tend to be large, averaging 400,000 ha in surface area (Figure 28—1, Table 28—1). Research is oriented toward maintaining and restoring natural ecological conditions or, in some cases, enhancing natural fish and wildlife values. The other group, consisting of 14 sites, is managed primarily for experimental research oriented toward sustaining or enhancing the productivity of managed ecosystems for human benefit. The reserves generally are of moderate size, averaging 18,000 ha.

The objective in the survey[2] was to identify conditions and trends indicative of apparent problems and successes relating to the network as a whole. Individual reserves sometimes differed widely from the overall network in terms of their strengths and weaknesses, and it was not attempted to assess such differences, although particular reserves may be referenced in an illustrative context.

Status of scientific activities

In the survey, field scientists were asked to provide their perception of the adequacy of various scientific activities in the reserve to meet the present and reasonably

[1]Since this paper was drafted in August 1981, an additional two sites in the United States — Guanica Commonwealth Forest Reserve and Big Thicket National Preserve — have been recommended for formal designation as biosphere reserves by the MAB Bureau at its October 1981 meeting. These two sites were not included in the survey described in this contribution.

[2]A more detailed description of survey methodology and results is available from the US-MAB Secretariat, Department of State, IO-UCS, Washington, D.C. 20520.

Table 28—1. Listing of biosphere reserves in the United States (as of August 1981).

Name of Reserve	State	Biogeographic Province and Coastal Region (where applicable)	Administrator[a]	Area in Hectares	Management Emphasis[b]	Year Designated by Unesco (D=dedicated)	Misc.[c]
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	
Great Smoky Mountains National Park	North Carolina / Tennessee	Eastern Forest — south	NPS	208,403	C	1976	
H. 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 — transitional (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

Table 28—1. *continued*

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	
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
[illegible]	[illegible]	Sierra Nevada-Cascade — south	NPS	343,000	C	1976	

	Tennessee						
H. 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 — transitional (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

Table 28—1. *continued*

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	
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	
Pending designation:							
Big Thicket National Preserve (12 units)	Texas	Austroriparian	NPS	34,217	C		
Guanica State Forest	Puerto Rico	Greater Antillean	PR	4,015	C		

[a] Abbreviations:
ARS — Agricultural Research Service (US Department of Agriculture)
BLM — Bureau of Land Management (US Department of the Interior)
FS — Forest Service (US Department of Agriculture)
FWS — US Fish and Wildlife Service (US Department of the Interior)
NPS — National Park Service (US Department of the Interior)
PR — Commonwealth of Puerto Rico
TNC — The Nature Conservancy.

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

[c] IBP — Research site for International Biological Programme, 1965-1975.
LTER — Pilot project site for long-term ecological research programme of the National Science Foundation, 1980-.

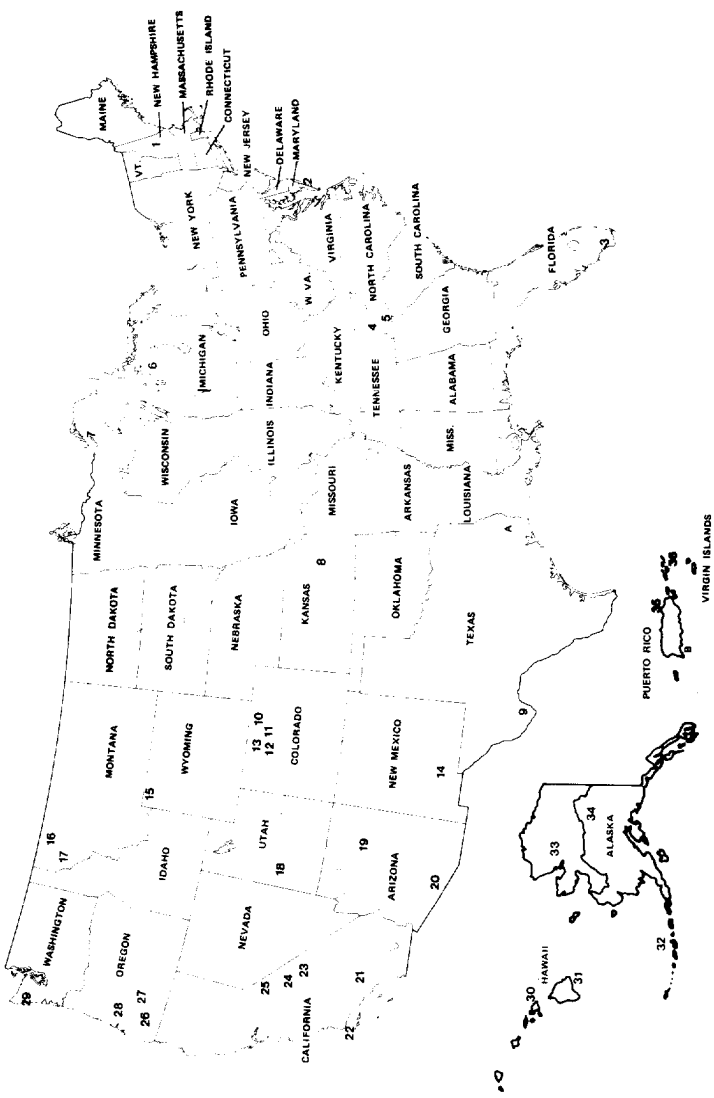

Figure 28—1. Biosphere reserves in the United States. 1. Hubbard Brook Experimental Forest, 2. Virginia Coast Reserve, 3. Everglades National Park, 4. Great Smoky Mountains National Park, 5. Coweeta Experimental Forest, 6. University of Michigan Biological Station, 7. Isle Royale National Park, 8. Konza 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. Coram Experimental Forest, 18. Desert Experimental Range, 19. Beaver Creek Experimental Watershed, 20. Organ Pipe Cactus National Monument, 21. San Dimas 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. Noatak National Preserve, 34. Denali (Mt. McKinley) National Park, 35. Luquillo Experimental Forest, 36. Virgin Islands National Park, *Nominated and Pending Designation:*
A. Big Thicket National Preserve, Texas,
B. Guanica State Forest, Puerto Rico

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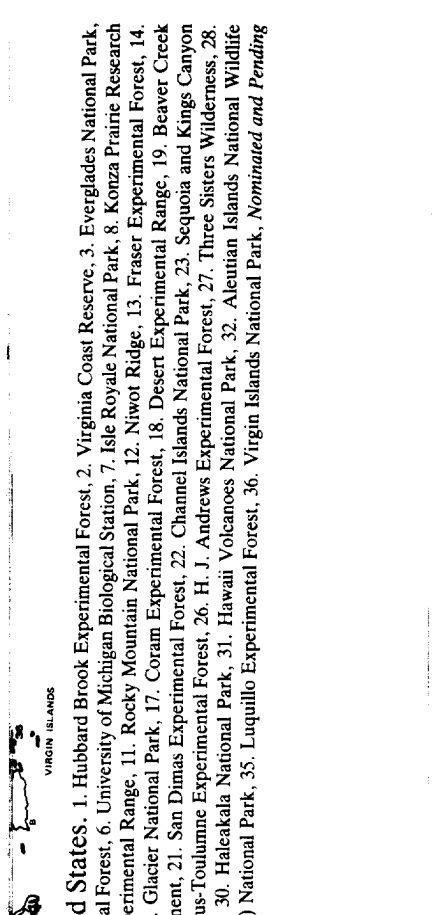

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foreseeable needs of scientists and managers. Activities were inventoried according to three broad types of scientific work: baseline information (30 activities), environmental monitoring (13 activities), and ecological research (39 activities). The survey revealed a very high variability in the perceived adequacy of the reserves' scientific and management needs. Some reserves report many comprehensive activities while others indicated inadequate work in numerous areas.

The 14 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 the 22 conservation areas focusses 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 System, though there are plans for selected reserves in Chile, USA and the USSR to take part in a pilot project on monitoring studies in temperate forest ecosystems. However, the survey suggests that most of the reserves are, for practical purposes, essentially autonomous study units.

A few of the topics for study 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 fields could impair the capability of the reserves to conserve genetic resources and habitats in the face of increasing human-caused threats.

Batisse (1980) and di Castri *et al.* (1981) have 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. These authors have 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, biosphere reserves should play a key role in this mission. However, apart from a few noteworthy initiatives, the biosphere reserve network in the United States is not as yet contributing very effectively in this area.

The problem seems to be due in part to the fact that the US 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

programmes tend to be directed toward limited objectives relating to a particular site, region, or area of inquiry.

The number of linkages among the programmes is disappointingly small. Our survey revealed that, of the 36 US reserves, 23 are involved in ongoing 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 focussed on a single activity. Instances of integration of demonstration and training into these programmes 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.

Facilities, staffing and funding

The survey results indicate that a reasonable level of basic facilities to support scientists' work is available in most, but not all, of the biosphere reserves. 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 it is known that facilities exist in most areas, but operations vary widely in adequacy. Figure 28—2 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. 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 programmes. The seven reserves with the largest scientific staff ($\geq$10 positions) all fall within the top-rated sites in the survey. However, although reserves with small ($\leq$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 programmes but that the lack of a large staff does not necessarily lead to serious inadequacies.

Since 1977, the average funding level for scientific study in biosphere reserves

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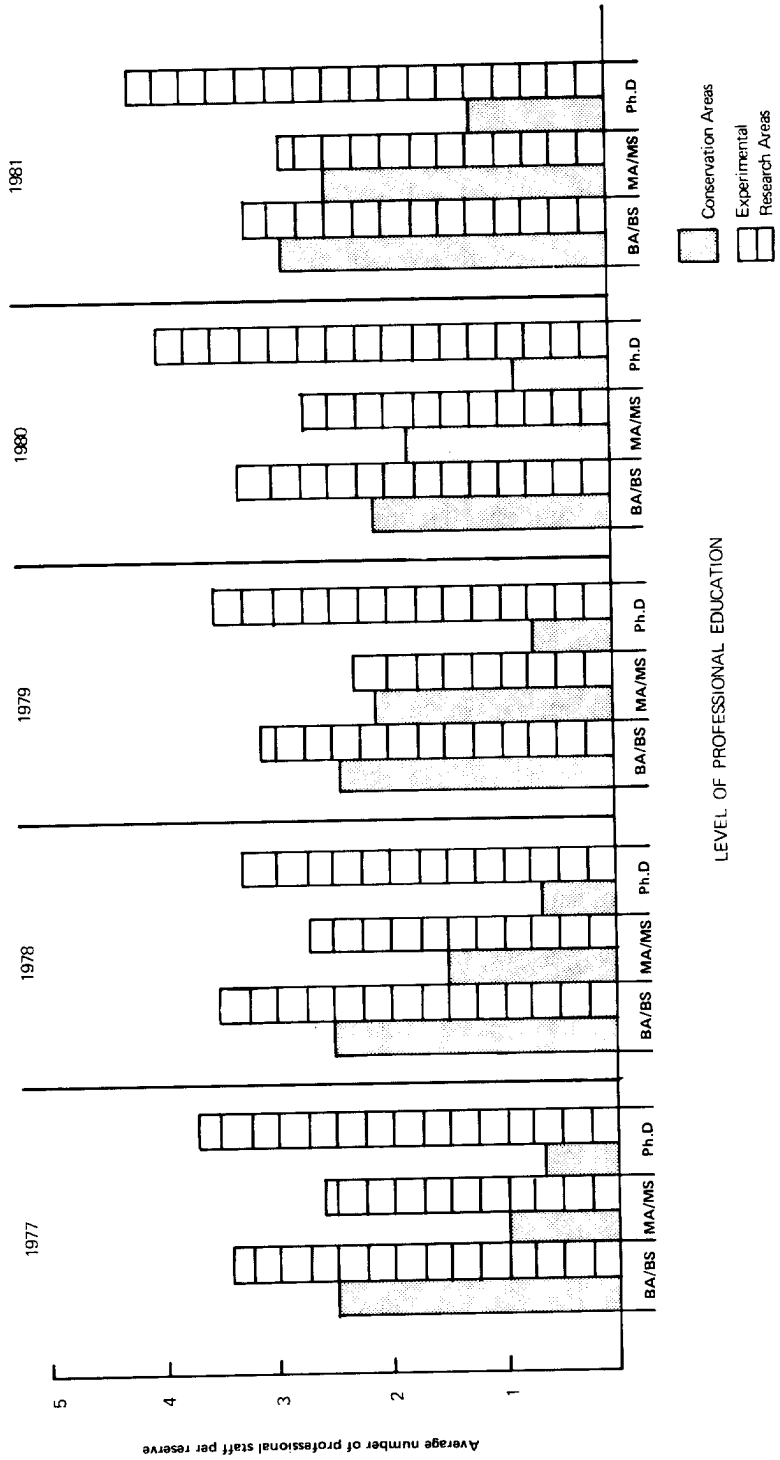


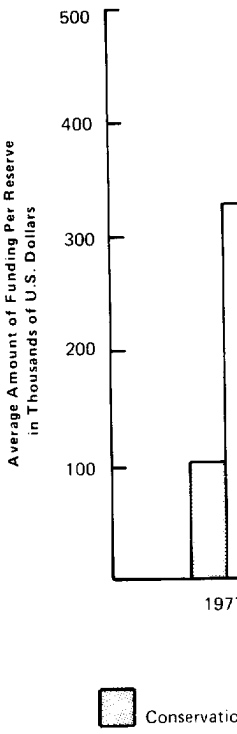
Figure 28—2. Professional staffing of US biosphere reserves, 1977 to 1981

has increased about 22 per cent in the experimental areas and about 93 per cent in the conservation areas (Figure 28—3). 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 1981, no funding was allocated for scientific study in two areas. Funding elsewhere was between 10,000 and 100,000 US dollars in 12 reserves, 101,000 and 400,000 US dollars in eight, 501,000 and 1 million US dollars in four, and more than 1 million US dollars in two. During the five-year period surveyed, three reserves, 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 two to three doctoral level scientists, and has an annual science budget of about 300,000 US dollars.

Anthropogenic threats and effectiveness in conservation

Information was requested on 49 anthropogenic threats in six categories. Table 28—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 per cent of the threats, a known or potential problem was indicated by a greater percentage of conservation than experimental areas. A much greater proportion of the conservation areas (≥20 per cent) reported threats for the majority of operations activities; 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 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. A greater percentage of reporting experimental areas was associated with only nine threats, and substantially greater percentage (≥20 per cent) 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 are being addressed through a science or management programme than in experimental areas (Figure 28—4). Intergroup differences exceeded 30 per cent for all categories except air pollution. Thus, although science programmes are rated as much less comprehensive in the conservation areas, they are much more likely to be focussed on detection and assessment of anthropogenic threats than in experimental areas. The growing number and



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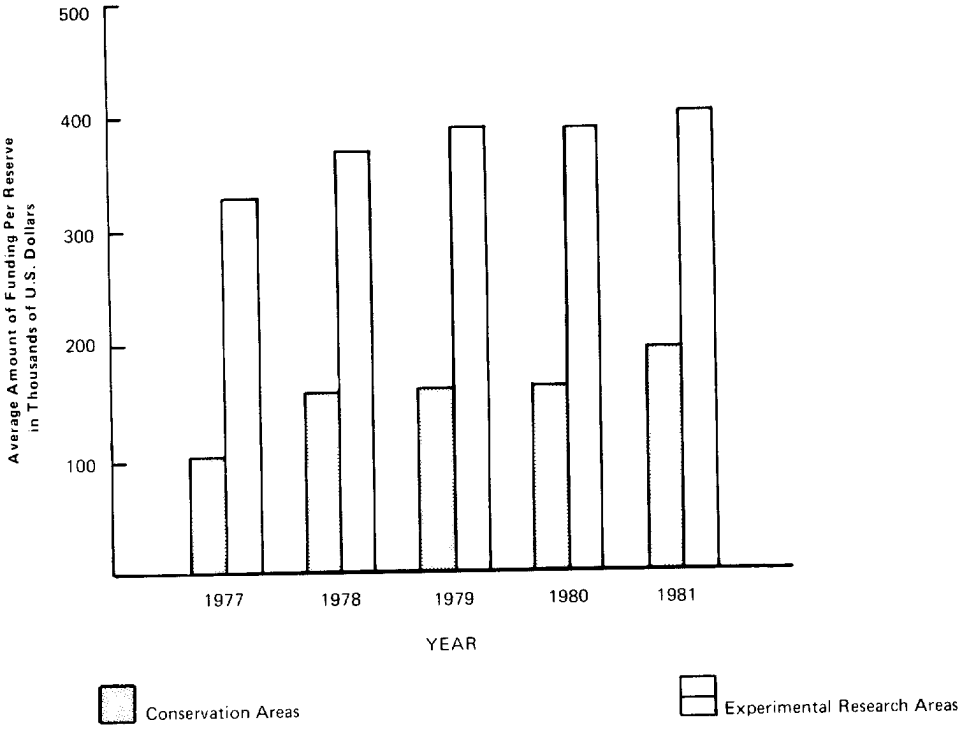

Figure 28—3. Funding for research in US biosphere reserves

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.

Respondents were asked 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. 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. 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 rare and endangered plants and animals. Fish — increasingly affected by acid precipitation, competition from exotics, and water pollution — were given the

Table 28—2. Percentage of biosphere reserves reporting particular threats (August, 1981).

Threat	Percent of Biosphere Reserves Reporting Documented or Suspected Threat		
	All Reserves (n = 36)	Conservation Areas (n = 22)	Experimental Areas (n = 14)
	%	%	%
AIR POLLUTION			
Acid rain	78	82	71
CO_2	56	59	50
CO	61	59	64
$(CH_3)x$	69	73	64
NO_x	67	68	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

Table 28—2. *continue*

Threat
PHYSICAL IMPACTS
ACTIVITIES
Campfires
Erosion
Habitat impacts
Off-road vehicles
Subtle influences
Trampling
Impacts on wildlife
WATER POLLUTION
Acid mine drainage
Changes in geotherm
Chemical pollution
Erosional deposition
Oil spills
Radioactivity
Sewage pollution
Toxic materials spills
Unnatural flooding face flow
Other

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servation Areas (= 22)	Experimental Areas (n = 14)
%	%
82	71
59	50
59	64
73	64
68	64
36	43
64	29
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Table 28—2. *continued*

Threat	Percent of Biosphere Reserves Reporting Documented or Suspected Threat		
	All Reserves (n = 36)	Conservation Areas (n = 22)	Experimental Areas (n = 14)
	%	%	%
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 or 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

lowest rating in the experimental areas, and second only to wide-ranging mammalian predators in the conservation areas.

The respondents' perception of threats and the degree to which their reserve's scientific activities are focussed on addressing them appear to influence their views on 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

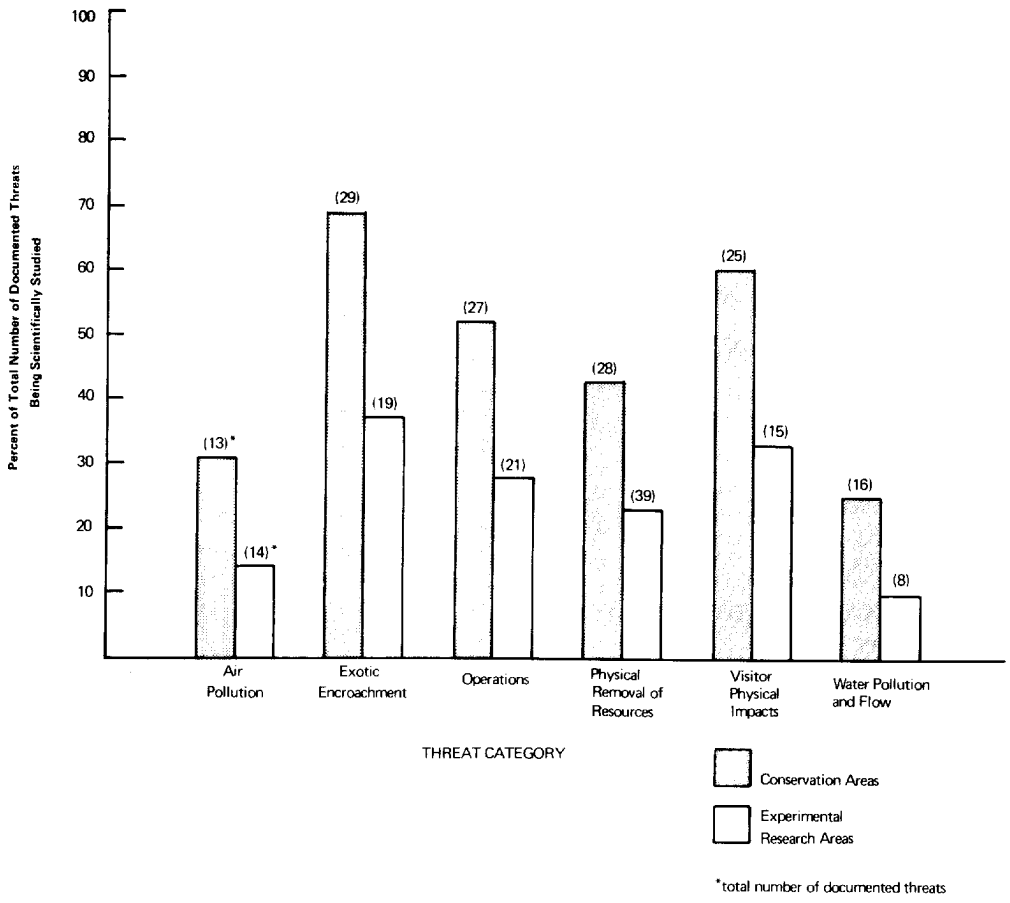

Figure 28—4. Status of scientific documentation for reported threats to US biosphere reserves

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.

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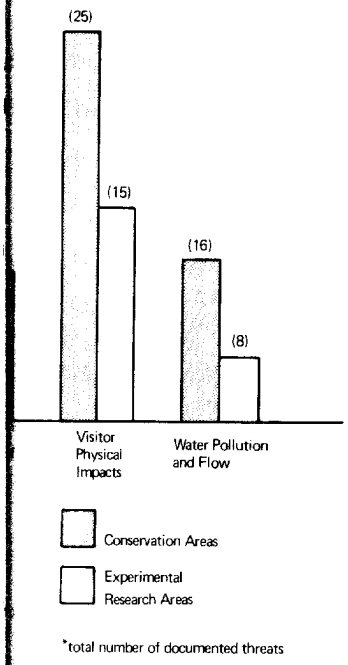

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Professional training

The amount of professional training 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. Twenty of the reserves are sites for training programmes to improve the scientific and resource management capabilities of administering government agencies, and three are planning to implement such programmes. 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 programmes of US reserves. Only five sites report ongoing training programmes involving other nations. Four additional reserves anticipate future initiation of bilateral cooperation activities involving Mexico, Canada, and the USSR, in conjunction with broader programmes 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 US biosphere reserves are major centres for public communication. In many of the experimental areas, considerable communication focusses on the reserve's scientific and management programmes, 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, and other special groups. The number of visitors to these reserves is not large. However, our survey respondents indicated that these visitors are, nevertheless, about four times as likely to find out about MAB and its concerns as visitors to the conservation areas.

Most conservation areas are national parks and monuments, and use a wide variety of media, facilities, and activities in public communication. In 1980, they received 27 million visitors. However, only 10 per cent of the conservation areas provide public communication on MAB (38 per cent for experimental areas). About 30 per cent of these reserves address global environmental problems to some degree (about the same as for experimental areas); 65 per cent discuss regional or national problems (versus 44 per cent for experimental areas); 70 per cent communicate information about science activities in the reserve (versus 63 per cent), and 95 per cent provide traditional interpretation of the reserve's natural history (versus 69 per cent). Four reserves report no public communication activities or facilities.

Major opportunities are apparently being missed to communicate information about interactions between human activities and natural ecosystems, and to link activities in the reserve with problems of local, 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.

Most respondents expressed reservations about the effectiveness of their public communication programme in conveying information about MAB, biosphere reserves, and interrelationships between human activities and the biosphere. About 70 per cent of the conservation and 77 per cent of experimental area respondents rated the reserves' programmes as less than effective in these fields. A surprising 97 per cent of the respondents felt that guidance from MAB would be of potential or definite value.

A US-MAB workshop on public communication in biosphere reserves held in July 1981 revealed that reserve personnel are often uninformed about MAB, biosphere reserves, and their role in dealing with local, national, and global problems. A better informed reserve staff was viewed as a 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 programmes, and reached agreement on a number of recommendations, some with potential applicability internationally (Gregg and Zube, 1981).

SOME FUTURE DIRECTIONS

Classification

Our experience with the Udvardy system of biogeographic classification (Udvardy, 1975) has been generally favourable, 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 local level. For this reason, systematic review of the ecosystems of a particular biogeographic province for biosphere reserve selection often requires adjustment of the province boundaries to fit the present state of knowledge regarding these ecosystem controls.

Urgent attention needs to be given to the matter of biogeographic classification in coastal regions, as the Udvardy system is not suitable for use here. To develop a basis for coastal biosphere reserve selection in the United States, a US-MAB expert panel was convened in 1980. Major tasks included developing a working definition and classification system for use in selecting reserves in the coastal zone.

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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 200 m depth) or (b) the limit of US 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 (Cowardin *et al.*, 1979; Ray, 1975), is now being tested on an experimental basis in selection of biosphere reserves in the Carolinean-South Atlantic Coastal region.

Selection criteria

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 nomination of the 12-site Big Thicket National Preserve in eastern Texas as a biosphere reserve 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 or through the cluster concept. The great majority of the sites in the multiple site 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. Periodic review of biosphere reserves is encouraged to 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 US 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 US 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 *et al.*, 1981; Ray *et al.*, 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.

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.

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 US 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 Secretary of the International Coordinating Council for MAB 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.

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. In August 1980, a prototype study was initiated in the Great Smoky Mountains Biosphere Reserve. 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 ecosystems 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 programmes 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 accord priorities to 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 programme 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 planned for other reserves.

Genetic resources protection and management

US-MAB, in association with various Federal agencies, has co-sponsored two major workshops dealing with genetic resources. The first of these took place in Washington, D.C. in November 1981. Its aim was to develop perspective on the problem of declining global genetic diversity. Specifically, it brought together scientists, resource managers, and agency administrators to assess the causes and magnitude of the problem; its economic, social, ecological, and politicial ramifications for the US and other countries; the status of institutional capabilities; and the effectiveness of existing US policies in dealing with the problem. Among other outputs, the workshop recommended initiatives to promote domestic and international efforts to maintain biological diversity (US Department of State, 1982).

The second workshop was held in Washington, D.C. in August 1982 and was concerned with the application of genetics to the management of wild plant and animal populations. This workshop provided new perspectives on the potential for managing the genetics of biological resources, with principal emphasis on temperate zones. It addressed problems in managing wild animals and plants 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 included species and declines and extinctions, the founding of new populations, the merging of separated populations, and maintaining the natural diversity of populations and taxonomic units. This workshop identified gaps in our knowledge, and developed 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. Eminent authorities in basic and applied sciences provided their perspectives to an audience of resource managers, policy-makers, and representatives from interested organizations, with the objective of bringing relevant information from diverse fields to bear on more effective management of biological resources in a rapidly changing world. Responses to this MAB initiative at the Federal, state and private levels were overwhelmingly positive; three Federal agencies and 17 scientific and conservation organizations sponsored the workshop. Complementary to these workshops is a major MAB publication on the cultural significance of the world's natural genetic resources which summarizes a wealth of practical information to support global efforts in genetic conservation (Oldfield, in press).

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CONCLUSIONS

During the upcoming second decade of MAB, the United States' expanding network of biosphere reserves will play an increasing role in the development of new scientific and technological capabilities to assess the causes and effects of changes in natural and man-modified ecosystems. Much improved standardization and intercalibration of inventory and monitoring methods will vastly increase our capability in comparative analysis of different ecosystems. As our understanding of the structure and function of ecosystems continues to increase, predictive ecosystem modelling will come into its own as a practical, reliable, and cost-effective tool of land management. Research in biosphere reserves will make major contributions in providing the basis for intensive management of habitats and genetic resources on an unprecedented scale, as biological refugia become progressively more isolated by regional land use changes and human activities.

It is recognized that the social, economic, and political context of conservation in the United States is unique, and that scientific and management advances made within this framework often do not apply to the situations of other nations. Nevertheless, there are many instances where these advances can be applied or adapted to other situations, and it is in this area that the US biosphere reserves can contribute most effectively to the solution of global problems through professional communication, coordination of related scientific activities, demonstration, and training. For the immediate future, the major challenge will be to find ways to support these activities under the prevailing conditions of global economic difficulties, which are increasing the sectorialism in governments and institutions, resulting in higher priority on furthering short-term national interests at the expense of the long-term interests of mankind.

We are rapidly entering an era in which technology may well permit us to sustain conservation and development in ways which assure a life of dignity for each of the world's citizens. However, technology can only be as effective as our will to direct it unselfishly toward the good of all mankind. In the context of an increasingly sectorial world, our best hope may lie in awakening the nascent yearnings and the fundamental unity of the human race, in which the ideals of our speech become the reality of our actions.

APPENDIX

An administrative history of the United States biosphere reserve network

Following the Unesco-sponsored "Biosphere Conference" of September 1968 at

which the MAB Programme was conceptually launched, and the Unesco General Conference of November 1970 at which it was programmatically established, United States scientists have been continually involved in the planning and development of MAB in general, and in particular MAB Project Area 8 ("Conservation of natural areas and the genetic material they contain"). After MAB's newly established International Coordinating Council recommended the establishment of the biosphere reserves network, these scientists helped generate significant support in the United States, both within the scientific community and in government. As a result, the United States was able to endorse enthusiastically the recommendation of the United Nations Conference on the Human Environment (Stockholm, June 1972) 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 (IUCN, 1974; Udvardy, 1975; Unesco, 1973). However, faced with the failure to obtain funds from international organizations to develop the network, 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 into actual establishment of biosphere reserve sites.

Following the summit conference, there was considerable enthusiasm in the United States for establishing the first biosphere reserves at the third session of the MAB's International Coordinating Council held in Washington D.C. in September 1974. Given the severe time constraint, US-MAB emphasized selecting outstanding, securely protected ecosystems representative of the nation's biogeographic provinces which 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, and Yellowstone. The agency's policies permitted experimental manipulations only in limited cases, where deemed essential to restore natural conditions and processes. In addition, the history of ecological study in many of these areas was limited. On

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Given these limitations, US-MAB developed the cluster concept, through which large conservation areas and much smaller experimental research areas would be paired to fulfill the multiple purposes of the biosphere reserve.

The United States announced its intention to establish an initial network of 16 biosphere reserves, most of them paired sites, at the MAB Council meeting in September 1974. During the next two years, US-MAB continued to identify suitable sites, which were submitted to the Council 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 by Unesco 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 to identify needs, objectives, and specific projects for individual reserves, and to develop a framework for coordinating activities at the regional, national, and international levels (US 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 MAB within both the public and private sectors; and many of the more than 100 recommended projects were subsequently implemented. Major initiatives were undertaken to synthesize information on biosphere reserves (Risser and Cornelison, 1979), and to develop pilot programmes for integrated pollutant monitoring (Brown, 1981; Wiersma, *et al.*, 1978). Since 1978, workshops have been held to develop separate guidelines for identification and selection of biosphere reserves in terrestrial and coastal areas (Fernald *et al.*, 1981, Ray *et al.*, 1981); to improve certain specific biosphere reserve functions, such as long-term ecological monitoring (US National Committee for MAB, 1979) and public communication (in preparation); as well as to develop cooperative programmes involving biosphere reserves in other nations, notably Mexico (USDA 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 responsible for work on tropical forests, temperate forests, freshwater ecosystems and conservation. 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 US dollars for projects lasting up to three years. In the 1981 fiscal year 480,000 US dollars 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 focussed 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 local, national, and sometimes international importance. With regard to the bilateral studies, it is worth noting that the Consortium funds the US side of projects which have bilateral support. This distinguishes it clearly from technical assistance programmes and promotes productive scientific relationships to which a substantial commitment exists on both sides.

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