

Biodiversity Conservation, Sustainable Development, and the U.S. Man and the Biosphere Program: Past Contributions and Future Directions

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Abstract—*U.S. Man and the Biosphere (MAB) Program is part of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) MAB program, and is one of six regional MAB programs that span the globe. The MAB Program was created in 1971 with the goal to explore, demonstrate, promote, and encourage harmonious relationships between people and their environments. Biosphere reserve networks are a primary vehicle for accomplishing MAB goals and serve four basic functions: 1) conserve biodiversity, 2) demonstrate sustainable development approaches, 3) support research and monitoring related to local, national, and global issues of conservation and sustainable development, and 4) build social capacity for sustainable development through education and training. The U.S. network, established in 1976, consists of 47 biosphere reserves that represent a diversity of ecosystems. The U.S. MAB program is in a period of reflection and revitalization as it nears 30 years of commitment and contribution to biological diversity conservation and sustainable development. Major accomplishments of the U.S. MAB program have been through many different institutions, such as the Information Center for the Environment's (ICE) development of a biodiversity database that serves to document species occurrences for protected areas around the world (www.ice.ucdavis.edu), the development of the monitoring and assessment of biodiversity program research and education activities by the Smithsonian Institution (www.nationalzoo.si.edu/conservationandscience/MAB), and Southern Appalachian MAB program's exemplary achievements in promoting environmental health and stewardship in natural and cultural ecosystems in the Southern Appalachian mountains. Future emphasis areas for the U.S. MAB program include refreshed operating principles based on a model of integrated human and natural ecosystems, enhanced networking capabilities among reserves within the U.S. and around the world, innovative advances in global change monitoring, sustainability research, and education at U.S. biosphere reserves, and accelerated development of solutions to key challenges to sustainability.*

Introduction

Sustainability is increasingly a focus of national and international attention in terms of dialogue, monitoring, research, development, and policy (Sayer and Campbell 2003). However, recognition of the importance of sustainability is not new—indeed, it is as old as human societies themselves (Diamond 1999). Over the past 50 years, many advances have been made in our understanding of the limitations and sensitivities of the biosphere, and in our use of technology to minimize detrimental effects of human activities on the environment. The United Nations Educational, Scientific, and Cultural

Organization's (UNESCO) Man and the Biosphere (MAB) program, founded over 30 years ago, is an example of a significant international effort to enhance and promote sustainability, and it has made significant contributions toward this goal, both in the U.S. and throughout many countries around the world. Much has changed since the 1970s, most significantly being that human populations have increased by approximately 50 percent, from 4 billion to 6 billion people globally, and similarly from 200 million to 300 million in the United States (U.S. Census Bureau 2004). As we begin a new millennium, it seems prudent to take stock of U.S. MAB's past accomplishments, operational short-comings,

current and future opportunities, and pressing priorities to sharpen its focus and continue its insightful offerings to tomorrow's sustainability challenges.

MAB Program Fundamentals

The MAB Program was launched in 1971 to facilitate intergovernmental cooperation in promoting harmonious relationships between people and their environments. As such, MAB was the first deliberate international initiative to work toward sustainable development. Specifically, the goals of the MAB program are to: (1) foster the rational use and conservation of the resources of the biosphere and the improvement of the global relationship between man and the environment; and (2) to predict the consequences of today's actions on tomorrow's world and thereby increase man's ability to manage efficiently the natural resources of the biosphere. U.S. MAB Program is one of six regional MAB programs in 97 countries that span the globe (UNESCO 2003). The United States was one of the first countries to establish a national MAB organization and begin establishing biosphere reserves as part of a national network. The United States is a member of the regional EuroMAB program, along with 30 other countries in Europe and North America. The objective of the U.S. MAB program mirrors those of the international MAB program with an added emphasis on a balance between social and ecological systems, "To demonstrate and advance a sustainable balance between conserving biological diversity and promoting human development while maintaining associated cultural values" [www.euromab.org/general_information/geninfo.html].

The U.S. MAB program consists of three primary components: a National Committee, Research Directorates, and a Biosphere Reserve Network. The National Committee is comprised of a diversity of entities, including federal agencies, academic institutions, and non-governmental institutions. The National Committee provides national direction for all aspects of the program, such as the establishment of research directorates, allocation of funds and resources to biosphere reserves, international relations, and fund raising. Research directorates are pivotal positions designated to promote focused research and education to further our understanding of ecosystem sustainability and speed the development, availability, and application of key information, useful tools, and effective practices. Five research directorates were established: temperate ecosystems, high latitude ecosystems, marine and coastal ecosystems, tropical ecosystems, and human-dominated ecosystems.

Biosphere reserve networks are the primary land-based vehicle for accomplishing MAB objectives and serve three basic functions: 1) conservation - contribute to the conservation of landscapes, ecosystems, species, and genetic variation; 2) development - foster economic and human development which is socio-culturally and ecologically sustainable; and 3) logistic support - support for demonstration projects, environmental education and training, research and monitoring related to local, regional and global issues of conservation and sustainable development (UNESCO 1995). UNESCO criteria for establishing a biosphere reserve are as follows: (1) contain a mosaic of ecological systems representative of a major biogeographic region, including a gradation of human influences; (2) contain areas significant for biodiversity conservation; (3) offer opportunities to explore and demonstrate approaches to sustainable development on a regional scale; 4) extend over an appropriately sized area to serve the first three functions; 5) identify appropriate zones (core, buffer and transition) to accomplish functions; 6) establish an organizational structure that provides for the involvement and participation of a range of authorities, communities, and interests; and 7) plans, programs, and policies that support the functions and activities of the biosphere reserve (UNESCO 1995). Biosphere reserves are intended to have three zones delineated: (1) one or more core areas, consisting of legally protected area(s) managed to sustain indigenous biota and natural processes; (2) a buffer zone, consisting of a legally or administratively established area that typically adjoins or surrounds the core area; and (3) a transition area, which surrounds the core area and buffer zone and supports a variety of resource uses and human activities characteristic of the larger region (fig. 1).

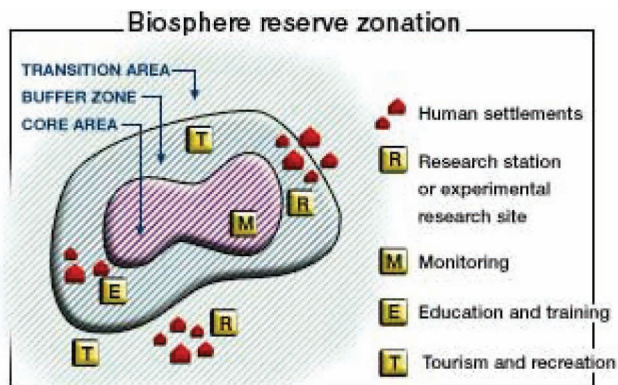


Figure 1. Three management zones associated with biosphere reserves (from UNESCO).

Highlights of U.S. MAB Contributions

Overall, UNESCO views MAB as instrumental in helping to reconciling conflicts between conservation and resource use by contributing to a more in-depth understanding of social-ecological interactions, and developing tools and techniques that can be used to implement ecosystem approaches promoted by Convention on Biological Diversity [www.biodiv.org]. The U.S. MAB program has made significant contributions to these ends in conserving biological diversity and promoting sustainable development in the U.S. and around the globe. Its contributions have taken a multitude of forms and have been accomplished through many different institutions.

Throughout the tenure of the U.S. MAB program, individual biosphere reserves have made a plethora of research, inventory, monitoring, and education contributions to local, regional, and international communities. In 1995, stellar contributions of 12 biosphere reserves were highlighted in U.S. MAB publication (Anonymous 1995). The cornucopia of activities included: a symposium on bioregional biodiversity sustainability; coordinated research between a U.S. and French coastal biosphere reserve on ecological sustainability issues; a regional workshop to introduce local educators to the objectives and activities of biosphere reserve programs; a cooperative research program to accomplish data compilation, analysis, and modeling for an ecoregion; and a multi-agency assessment of water quality within a large-scale community watershed.

In the 1980s, the Smithsonian Institution, as a partner in the U.S. MAB program, developed their Monitoring and Assessment of Biodiversity program (www.nationalzoo.si.edu/conservationandscience/MAB). The mission of the program is to enable the implementation of biodiversity monitoring projects and to inform adaptive management planning around the world. Over its nearly 20 years of operation, this program has made substantial advances in research, development, and education in the arenas of biodiversity inventory and monitoring. For example, they offer formal educational opportunities in the form of intensive courses in biodiversity assessment and monitoring, and environmental leadership. They also have an active research program in over 10 locations around the world that strives to accomplish four main objectives: 1) test and implement protocols for long-term, multi-taxa monitoring of forests; 2) establish biodiversity assessment and monitoring projects to further regional conservation needs; 3) provide data management and analytical procedures that allow rapid assessment and dissemination of information, and 4) coordinate the

interactive biodiversity monitoring network to facilitate information exchange and dissemination, and the formation of data quality standards.

In the late 1980s, the Southern Appalachian Biosphere Reserve was designated, along with establishment of the associated Southern Appalachian Man and the Biosphere (SAMAB) program and cooperative agreement codifying the collaborative intentions of several agencies (ultimately 14 federal and state agencies) (Van Sickle and Turner 2001). SAMAB's vision is to foster a harmonious relationship between people and the Southern Appalachian environment. Over the course of its existence, SAMAB it has garnered exemplary achievements in promoting environmental health and stewardship in natural and cultural ecosystems in the Southern Appalachian Mountains, and has demonstrated the remarkable potential that biosphere reserves have to bring people and resources together to achieve shared sustainability goals and objectives. Southern Appalachian Biosphere Reserve consists of six core areas including one national park (Great Smoky Mountains), two research areas, a state park, and two nature preserves. One of its greatest single contributions to date has been to lead the acclaimed Southern Appalachian Assessment, which provided a detailed accounting of the status of the Appalachian ecosystems and identified key areas of concern and opportunity to meet sustainability objectives throughout the ecoregion (SAMAB 1996).

In the early 1990s, the Biosphere Reserve Inventory and Monitoring database was created to house and disseminate information on the biodiversity of biosphere reserves around the world. The utility and scope of the database eclipsed its original goal during the first decade of its existence to become a world-class resource as the Biological Inventory of the World's Protected Areas. The database is currently managed by the Information Center for the Environment's (ICE) at the University of California at Davis, and is readily accessed through the world wide web from any where in the world (www.ice.ucdavis.edu).

Throughout the 1990s, research directorates administered research that addressed one or two priority topics areas with respect to their ecosystem types, and together they completed seven major research projects addressing pressing sustainability challenges such as ecosystem management approaches to achieve ecological sustainability south Florida wetland ecosystems, caribou population and management dynamics in the arctic, ecological and socio-economic impacts of management strategies for marine protected areas in three different oceanic areas, and the development of a land use change analysis system for modeling landscape-scale change at the ecoregional scale. In addition to large research projects, research directorates also distributed small

grants to support student research projects on biosphere reserves.

The new millennium brought about many changes in the U.S. MAB program. In 2000, administration of the U.S. MAB program was transferred from the State Department to the U.S. Forest Service, and the U.S. MAB Secretariat and chair of the National Committee was conveyed to the Associate Deputy Chief for Research and Development in the U.S. Forest Service. The Forest Service has been engaged in updating the U.S. MAB program since 2000. In 2003, the United States rejoined UNESCO after a 19 year hiatus. Rejoining UNESCO brought with it renewed interest and optimism about the potential of the U.S. MAB program to continue to make significant contribution to sustainability challenges in the 21st century. The first U.S. Biosphere Reserve Association was also formed in 2003 (www.samab.org/about/usbra/usbra.html). The U.S. Biosphere Reserve Association is a non-profit organization dedicated to three primary aims: 1) provide leadership and support for the biosphere reserves; 2) convey factual information about the purposes and activities of biosphere reserves; and 3) develop cooperation among biosphere reserves in North America.

The U.S. Biosphere Reserve Network

UNESCO regards the world network of biosphere reserves as MAB's most visible asset and operation tool in the 21st century, and a key mechanism by which priority work on sustainability issues will be accomplished. Similarly in the U.S., the biosphere reserve network is viewed as a collection of landscape for learning that uniquely positions MAB to provide leadership and deliver substantive contributions toward sustainability in the U.S. At the global scale, external recognition for the unique value of the world network of biosphere reserves has come in the form of the prestigious Concord Award in 2001 from the Prince of Asturias Foundation. The award acknowledges its 30 years of contributions to the conservation of unique natural areas and associated species that are the heritage of mankind, and to opening new horizons of knowledge about how to protect and preserve ecological and cultural treasures (www.fps.es/ing/premios/galardones/galardonconcordia2001.html).

The U.S. biosphere reserve network consists of 47 biosphere reserves (fig. 2); about 60 percent were established



Figure 2. U.S. MAB biosphere reserve network (from UNSECO).

Table 1. Biosphere reserves in the U.S. MAB network.

Biosphere Reserve Name	Administrative Offices	Number of Units
Aleutian Islands	Adak, AK	1
Beaver Creek	Flagstaff, AZ	1
Big Bend	Big Bend, TX	1
Big Thicket	Beaumont	1
California Coast Ranges	Northern coast, CA	8
Carolinian-South Atlantic	Coast, SC	11
Cascade Head Biosphere	Corvallis, OR	1
Central Coast Biosphere	Stanford, San Francisco, Stinson Beach, Corte Madera, Burlingame, Glen Ellen, Bodega Bay, Neward, Novato, and Point Reyes, CA	14
Central Gulf Coast Plain	Eastpoint, FL	1
Central Plains	Ft. Collins and Nunn, CO	1
Champlain-Adirondak	Ray Brook, NY and Waterbury and Rutland, VT	3
Channel Islands	Santa Barbara and Ventura, CA	2
Coram	Missoula, MT	1
Denali	Denali, AK	1
Desert	Provo, UT	1
Everglades & Dry Tortugas	Homestead, FL	1
Fraser	Ft. Collins, CO	1
Glacier Bay-Admiralty Island	Juneau and Gustavus, AK	2
Glacier	West Glacier, MT	1
Guanica	Guanica, Puerto Rico	1
H.J. Andrews	Corvallis, OR	1
Hawaiian Islands	Hawaii and Maui, HI	2
Hubbard Brook	Campton, NH	1
Isle Royale	Houghton, MI	1
Jornada	Las Cruces, NM	1
Konza Prairie	Manhattan, KS	1
Land Between the Lakes	Golden Pond, KY	1
Luquillo	Rio Piedras, Puerto Rico	1
Mammoth Cave Area	Bowling Green, KY	1
Mojave and Colorado Deserts	Palm Desert, Borrego Springs, Death Valley, San Bernardino, and Twentynine Palms, CA	5
New Jersey Pinelands	New Lisbon, NJ	1
Niwot Ridge	Nederland, CO	1
Noatak	Fairbanks and Kotzebue, AK	2
Olympic	Port Angeles, WA	1
Organ Pipe Cactus	Flagstaff and Ajo, AZ	1
Rocky Mountain	Estes Park, CO	1
San Dimas	Riverside, CA	1
San Joaquin	Fresno, CA	1
Sequoia-Kings Canyon	Three Rivers, CA	1
South Atlantic Coastal Plain	Hopkins and Georgetown, SC	1
Southern Appalachian	Knoxville, TN	6
Stanislaus-Tuolumne	Sonora, CA	1
Three Sisters	McKenzie Bridge, OR	1
Univ. of Michigan Biological Station	Ann Arbor, MI	1
Virgin Islands	St. John, Virgin Islands	1
Virginia Coast	Nassawadox, VA	1
Yellowstone	Jackson Hole, WY	1

in 1976 and the remaining ones established over the following 15 years. Thirty-nine of the reserves are located across the contiguous U.S., with an additional four in Alaska, one in Hawaii, two in Puerto Rico, and one in the Virgin Islands. The 47 reserves span a diversity of ecosystem types, including terrestrial and marine ecosystems. The U.S. biosphere reserve network is unique relative to networks in most other countries in a number of features. First, unlike most of the 393 reserves in other countries,

almost all of the reserves in the U.S. were established in areas that were already designated for conservation or research purposes (table 1). Specifically, the majority (> 60 percent) of the biosphere reserves in the U.S. are associated National Parks. USDA Experimental Forests are the next most prevalent association (17 percent), with the remainder located on a smattering of different lands, such as state forests, U.S. Fish and Wildlife National Wildlife Refuges, Bureau of Land Management

lands, University properties, and Nature Conservancy properties. Thus, biosphere reserve designations did not increase the amount of land set aside for conservation in the U.S., but rather served to strengthen and broaden the emphasis of unit management to encompass research, monitoring, development, education, and demonstration of sustainability practices. Second, a large proportion (> 30 percent) of reserves consists of multiple core areas (in other words, individual administrative units). Reserves with multiple units serve an important function in the US. MAB network because they present a complex administrative scenario where multiple and potentially conflicting mandates of various units need to be considered and management options are negotiated to best meet the shared objectives and individual needs of each unit. Thus, multiple unit reserves have some of the same management challenges as buffer and transition areas. Finally, most U.S. biosphere reserves do not have buffer or transition areas designated. This is largely a function of the reserves being based on previously designated areas that only consisted of core reserve areas with a single set of objectives. A few of the reserves (for example, Mammoth Cave Area Biosphere Reserve) have proposed zones of cooperation, which are intended to serve a similar function as buffer and transition areas.

In some respects, reserves without designated buffer and transition areas serve as ecological and social experiments in the value and necessity of buffer and transition areas in meeting the objective of maintaining biological diversity of core areas. The evolution of boundary designations and land management in and around Yellowstone National Park is a prime example. Yellowstone National Park was the first national park in the U.S., established in 1872 (USDI 2004), and it was designated as a biosphere reserve in 1976 with only the core area of the park designated (no buffer or transition areas). The park itself extends over a 900,000 ha area. The concept of a Greater Yellowstone Ecosystem came into being in the mid 1980s, driven by the recognition that many of the values for which the park was established were dependent upon the management of lands outside the park. As such, the Greater Yellowstone Ecosystem was established to maintain the important ecological and social linkages across the headwaters of three major river systems – Yellowstone, Snake, and Green rivers – and thereby maintain ecosystem integrity, including populations of wide ranging species that require large landscapes to persist, such as grizzly bear, wolverine, lynx, and gray wolf. The Greater Yellowstone Ecosystem currently occupies a 7 million ha area centered on Yellowstone National Park, including two National Parks, portions of six national forests, three national wildlife refuges, BLM lands, state lands, and private and tribal lands (Clark

and Minta 1994; Shullery 1995). A future review of the Yellowstone Biosphere Reserve is likely to conclude that the boundaries of the Greater Yellowstone Ecosystem function as a zone of cooperation and should be designated as such within the MAB program.

UNESCO states that biosphere reserves are to be reviewed every 10 years to evaluate their effectiveness and needs. Toward this end, a survey of biosphere reserves in the U.S. was conducted in 1995, and repeated in 2003, to determine their functional strengths and needs (Gilbert 2004). The survey asked each reserve to provide their perspective on the state and future of U.S. biosphere reserves. Five primary questions were asked of managers: 1) what are the management benefits to your biosphere reserve, 2) who is participating, 3) what resources are needed, 4) who identifies with the biosphere reserve concept, and 5) who is concerned about or opposed to the biosphere reserve. A number of substantive conclusions came from the most recent survey. Biosphere reserve status conferred management benefits for most reserves, and benefits were greatest in the areas of promoting an ethic of sustainability, research, public consultation and participation, environmental awareness, ecosystem management, and improved cultural resource protection. Academic research institutions were the most prevalent participants in the biosphere reserve activities, followed by federal agencies. Few units experienced expressions of concern by local communities and organizations. Perhaps most importantly but not surprising is that funding was the most limiting factor, followed by limited local involvement and infrequent communication among biosphere reserve managers. Without funding from the MAB program, the mission of units tends to shrink back to the core mission of the unit's original designation, and most frequently that means that programs directed toward sustainable development atrophy. Finally, responses were quite similar in 1995, with some changes in the focus of programs. Since 1995, areas of emphasis for biosphere reserves have shifted from conservation and ecosystem management to research and education.

The ecological status of U.S. biosphere reserves has never been evaluated as a network. Given that most biosphere reserves are co-located with national parks, we consulted the results of the National Parks Conservation Association's (NPCA) annual evaluation of national parks (www.npca.org) as a small window into their status. Every year the NPCA identified the 10 most endangered National Parks out of the 387 units designated in the National Park system. In 2003, 5 of the 10 most endangered National Parks are also biosphere reserves (Big Thicket National Preserve, Everglades National Park, Great Smokey Mountains National Park, Organ pipe cactus National Monument, and Yellowstone National

Park). Predictably, biosphere reserves co-located with National Parks will suffer from the same set of stressors that affect the parks, namely air and water pollution and recreation impacts. A more thorough evaluation of the status of the ecological status of biosphere reserves would be a valuable tool to guide future investments in biosphere reserve management and considerations for additions to the network.

Future Directions

The U.S. MAB program is in a period of reflection and revitalization as it contemplates its future commitment and contributions to biological diversity conservation and sustainable development. Much has transpired over the last three decades, including advancement of our understanding of ecology, ecosystem dynamics, and sustainability thresholds and threats. Similarly, many national and international programs have been created with the intent of achieving a variety of biodiversity conservation and sustainability objectives (for example, the Long-Term Ecological Research Network and the National Center for Ecological Analysis and Synthesis). At the same time, it is clear that sustainability challenges continue to mount. At the Johannesburg World Summit on Sustainable Development in 2002, it was determined through exchange and discussion by thousands of participants, including over 100 heads of state, that growing poverty and increasing environmental degradation are threatening sustainability at local to global scales. The Summit intended to focus the world's attention toward meeting the challenge of improving people's lives and conserving natural resources in the face of growing human populations and association demands for resources. Given the limited progress that has been made since the Rio de Janeiro Summit in 1992, there is now an urgency

to take substantive action, and the U.S. MAB program could play a pivotal role.

It is incumbent upon the U.S. MAB program to take a multitude of factors into consideration in charting its course for the future. Certainly, the draft recommendations from the Johannesburg World Summit will outline keystone steps in the pursuit of sustainability. Similarly, the 2002 Convention on Biological Diversity generated broad objectives for 2010 that mirror those of the 2002 World Summit on Sustainable Development – poverty reduction and slowing the current rate of biodiversity loss at the global, national, and regional levels (www.biodiv.org). Specific approaches and actions have been generated by the MAB program through two seminal conferences. MAB program representatives from over 40 countries convened in Seville, Spain in 1995 to examine past experience in implementing the innovative concept of biosphere reserves, and to look to the future to identify what emphases should now be given to their three functions of conservation, development and logistical support. The result was Seville Strategy, which contains 11 objectives and associated recommendations for improving the national and bioregional effectiveness of the MAB program (table 2) (UNESCO 1996). A subsequent meeting in 2000 resulted in another document that provides further refinement to the original strategy in the form of a checklist for priority actions referred to as Seville+5 (UNESCO 2000). These recommendations are tailored specifically to the MAB program and provide a clear set of actions that will assist in directing and energizing the U.S. Program.

In summary, retooling the U.S. MAB program for success over the next few decades to will undoubtedly updating many of its elements. A refreshed set of objectives and operating principles based on a model of integrated human and natural ecosystems is needed. An increased emphasis on the interface between

Table 2. Four goals and 11 objectives articulated in the Seville Strategy (recommendations for action are available).

Goal I: Use of biosphere reserves to conserve natural and cultural diversity

- Improve the coverage of natural and cultural biodiversity by means of the World Network of Biosphere Reserves.
- Integrate biosphere reserves into conservation planning.

Goal II: Utilize biosphere reserves as models of land management and of approaches to sustainable development

- Secure the support and involvement of local people.
- Ensure better harmonization and interaction among the different biosphere reserve zones.
- Integrate biosphere reserves into regional planning.

Goal III: Use biosphere reserves for research, monitoring, education, and training

- Improve knowledge of the interactions between humans and the biosphere.
- Improve monitoring activities.
- Improve education, public awareness, and involvement.
- Improve training for specialists and managers.

Goal IV: Implement the biosphere reserve concept

- Integrate the functions of biosphere reserves.
 - Improve the strength of the World Biosphere Reserve Network.
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human-dominated and wildland ecosystems will guide revisions and additions to the reserve network (for example, urban biosphere reserves), as well as within-reserve activities. Enhanced networking capabilities among reserves within the U.S. and with other countries is critical to speed the exchange of ideas and the application of innovations. Global climate change has been identified as a sustainability challenge that biosphere reserves can make a unique contribution, as evidenced by the recent MAB Global Change Monitoring Initiative (UNESCO 2004). The U.S. biosphere reserve network contains a number of high elevation and island ecosystems, and has the opportunity to contribute to global change challenges. Finally, national direction and support is essential to promote and advance much needed education and capacity building activities at multiple scales. The U.S. MAB program is poised at the event horizon of a new century of promise and challenges, and holds great potential to contribute substantially to the goals, objectives, and challenges in the pursuit of sustainability in the decades ahead.

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