LONG-TERM ECOLOGICAL MONITORING
IN BIOSPHERE RESERVES
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This report describes the results of an international workshop on Long-Term Ecological Monitoring in Biosphere Reserves, held in the United States from October 20-28, 1978, to develop a plan for conducting such projects. The U.S. Man and the Biosphere Program hosted the workshop in cooperation with UNESCO and UNEP, forty-five scientists from ten nations and the United States attended the meeting.

Foreign participants arrived in Washington, D.C. on October 20, 1978, for briefings on U.S. MAB activities and to report on efforts underway in their respective countries. All participants then visited two Biosphere Reserves (Great Smoky Mountains National Park and Coweeta Hydrologic Laboratory), and support facilities at Oak Ridge National Laboratory. This region forms the U.S. Appalachian Biosphere Reserve cluster and was chosen as the first site of a U.S. pilot monitoring project in 1976.

The philosophy around which the Biosphere Reserve long-term monitoring plan was developed is based on the following precepts:

1. All ecosystems are undergoing long-term natural and anthropogenic changes which can only be understood

through the acquisition and examination of long-term data sets.

2. Land managers and policy-makers are in an improved decision-making position when basic information is available on a timely basis.
3. Synergisms can result through increased cooperation between the many organizations which conduct ecological monitoring and related activities.

Four categories were developed - chemical, biological, geo-physical, and anthropological and each is accompanied with an explanation text and a table outlining the desired level of effort.

Participants and other selected experts have had the opportunity to comment on earlier drafts of this report and it is hoped that the many helpful comments and suggestions are properly included. I would like to thank those who contributed the considerable time and effort needed to eliminate duplication and assure that the various levels were fully integrated and realistic.

Jeffrey B. Tschirley
U.S. Man and the Biosphere Program

For purposes of this report, the phrase "long-term ecological monitoring" shall refer to the process by which selected chemical, physical, biological, and anthropological variables are systematically observed, measured and interpreted for defined purposes; such purposes to be directed toward a description of the state of the environment, the identification of trends in it, and the assessment of pollutant effects.

LONG-TERM ECOLOGICAL MONITORING IN BIOSPHERE RESERVES

Ecological monitoring has enjoyed recognition from the international scientific community for many years. In 1964, the International Council of Scientific Unions (ICSU) created the International Biological Program (IBP) to organize a research effort aimed toward an improved understanding of the interrelationships of major ecological processes. The program required expertise of scientists from many disciplines and led to the development of extensive biome data bases.

The Scientific Committee on Problems of the Environment (SCOPE), founded in 1969, carries out activities related to monitoring through a number of institutions, one of them being the Monitoring Assessment Research Center (MARC) who are involved in the development of monitoring models for global pollutants.

The Food and Agriculture Organization (FAO) is involved in monitoring land uses ranging from forest cover to rangeland grazing; the World Meterological Organization (WMO) has set up a global network of stations to monitor climate, air pollution, and other variables; the World Health Organization (WHO) monitors the transport and effects of pesticides in relation to established safety levels; the Economic Commission for Europe (ECE) has recently instituted a cooperative program for monitoring air pollution in many western European countries; many MAB research projects in member countries are engaged in monitoring aspects of air, water, or soil. Clearly numerous programs, 16

national and international in scope, are attempting to bring together diverse disciplines to assess the condition of the environment.

The Scientific Committee on Problems of the Environment (SCOPE) reported in 1971 that:

> "The imperfectly understood cause and effect relations and environmental budgets of many substances have given rise to important questions about the complex interactions between man and the bioenvironment. A Programme must be initiated to obtain a picture of how all these processes occur, the rates at which they take place, the timing and nature of equilibrium situations, their effects on man the life-support systems of air, water, soils, climate and biota.

At the Stockholm Conference on Environment in 1972, the United Nations recognized the critical role of natural systems in political, economic, and social problems when it created the United Nations Environment Programme (UNEP). In 1975, Global Environmental Monitoring System (GEMS) actively began monitoring certain trends in the human environment. GEMS has long recognized the need to determine baseline values in representative ecosystems and the role that Biosphere Reserves can play. GEM's Kenya Regional Ecological Monitoring Unit (KREMU) monitors key elements of the region and is an important start toward establishing global baselines.

The major objectives of the UNESCO MAB Project 8, Biosphere Reserves are: to promote the conservation of representative ecosystems, with their full array of component species, as a strategy for maintaining genetic diversity; to provide sites for long-term research on the structure, functioning and dynamics of ecosystems and on comparisons between ecosystems, thus serving as a logistic base for other ecological research activities; to provide sites for monitoring of environmental change; and to make available facilities for education and training. To achieve these objectives, an international network of protected representative ecosystems, or Biosphere Reserves, is being established in both natural and man-modified areas, and formally designated Biosphere Reserves had already been set up in a number of countries. Biosphere Reserves in undisturbed, representative, natural ecosystems can serve as baseline areas for monitoring and research activities to be undertaken in the Global Environmental Monitoring System (GEMS) for UNEP.

The Biosphere Reserve long-term monitoring plan attempts to provide comparable data of global and regional nature while serving the needs of all countries. A flexible system was designed which can be adapted to a range of conditions. Four categories of monitoring activities were identified - biological, geo-physical, chemical, and anthropological. Three broad levels were established in each category progressing from the first, which gathers basic information on the features and resources of the site, to the second and third levels where more extensive and intensive monitoring of ecosystem functions takes place.

At level one, a core of parameters are measured in all Biosphere Reserves which relate broadly to global, regional, and local trends in the environment. Basic information is needed on features such as climatic conditions, major plant and animal communities, land use, physical features and land tenure.

Information gaps are identified and measurements started to provide critical data for activities at levels two and three. Emphasis should be placed on simplicity and reliability so that studies made at different sites or times or by different investigators may be compared with confidence. The modest collection of a few key samples perhaps insects, tissues of major plant or animal species, or air and water, can be invaluable with proper site and time information while cost would be low.

Selected parameters may be identified as being keystones in the ecology of an area, and merit special consideration. In some cases (e.g., a declining species population) the information obtained may be specific to the Biosphere Reserve or the area surrounding it; other parameters may be of global significance, such as the carbon cycle or heavy metal accumulation.

An important step which every country should take at the earliest stage is the identification of key individuals and institutions in the country for each of the four monitoring categories who can provide technical expertise for the parameters being monitored, coordinate activities between categories, and refer individuals carrying out projects to proper reference materials. Such a monitoring council can encourage project development, common methodologies, and act as a link to other projects.

Level two continues to build an information base, but also begins to utilize the data established in level one to assess key processes and identify additional parameters.

For example, the measurement of biological processes is important to long-term monitoring to determine rates and directions of change relative to other areas. However, such studies require level one information from other categories but are generally more complex than those of level one, Productivity measurements, comparable within vegetation types, are strongly encouraged so that intercomparisons can be made. The level two program relates to measuring regional trends which may be the most effective method in determining the global health of the environment.

While level three is the most sophisticated and technologically intensive, it does not necessarily represent a required level of effort for all Biosphere Reserves. It is designed to examine global, regional, and local parameters considered most vital to human well-being and ecosystem functioning. Projects are carried out primarily based on hypotheses developed through levels one and two and are intended to provide intense, sophisticated study of key aspects of the system. A handful of global parameters will be measured in enough Biosphere Reserves to provide good data. Similarly, at the regional, national, and local levels specific reserves will be identified for appropriate intensive studies.

Long-term monitoring programs in MAB Biosphere Reserves must serve the dual purpose of providing useful information to research and management units and to comparative studies among members of the Biosphere Reserve network to identify national, regional, or global trends in environmental quality. Programs range from simple surveys to highly sophisticated technologies, but all should be cognizant of the requirements of utility, comparability, and a degree of standardization in methodology, and the frequency and manner of reporting. It is again emphasized that no single monitoring category is independent of the others, and as projects are developed a balanced set of parameters must be utilized. Each program must be well-planned, and priorities flexible, economical, and scientifically feasible over the long term. Ecological change may be signaled by species population fluctuations, changes in water or air quality, detectable responses of "indicator" organisms, or alterations of process rates. Sampling strategies should depend on the spatial and temporal distributions of phenomena being measured. Permanent plots size varies also, particularly among different ecosystems. Clearly, to obtain representative view, a core of long-term monitoring parameters and measurement techniques must be comparable at different sites to determine whether recorded changes are due to man-caused shifts in the system, reflections of methodology, or biological variation within an ecosystem. At the same time, flexibility must allow sites or clusters thereof, the opportunity to pursue areas of study leading to a better understanding of local or regional issues. The following plan for monitoring in Biosphere Reserves is intended to contribute to that effort.

CHEMICAL

Monitoring of chemical elements and compounds establishes baselines and scales of comparison through examination of specific nutrients and pollutants. The area is closely tied with the other categories in both the minimum program and the levels. Chemical monitoring focuses on five sections of the enviornment with the objective of measuring nutrient input and status and the detection of undesirable substances, their transport (long-range and within a system), transformations, and effects on ecosystem and human health. The detection of pollutants and monitoring of natural substances comes through examination of the atmosphere, precipitation, surface water, soil and litter, vegetation, and animals.

Given the scope of this subject area, particular efforts must be made to develop an effective quality control program so that valid comparison of data can be made. Sampling and sample storage, chemical analysis, and data interpretation should be standardized, yet in practice, this is difficult to achieve. As a minimum, quality control of participating laboratories through the analysis of replicates and standard samples is desirable.

Level I.

Objective: pH and conductivity measurements in rainfall and surface waters; columns (1) and (2). This minimum level monitoring program is recommended for remote areas and other locations where equipment and personnel are not readily available to carry out a wider range of chemical monitoring.

Recommendations: pH and conductivity can be considered as gross indicators of changes in the ionic composition of rainfall and surface water. Conductivity is a measure of the total ionic concentration and pH is a measure of acidity which is related to concentration of such anions as nitrate, sulfate, and chloride. Because these measurements are relatively simple to carry out, it is recommended that they be conducted in the field at the time that the samples are collected.

Frequency - monthly

Equipment - pH and conductivity meters

Product: As integrators of properties associated with concentrations of both cations and anions, long-term changes in these measurements can be correlated with data from other sites where other monitoring programs are carried out. This will allow inferences to be made as to the magnitude of inputs of substances from the atmosphere and the effect on surface waters.

Level II

Object: To measure selected cations and anions in atmospheric deposition, surface waters, accumulation in animals, soil, litter and vegetation, and atmospheric gasses and particulates; columns (1) through (8). Information from this level surveys and establishes baselines in parameters with the intention of identifying those of possible global or regional significance.

Recommendations: Since deposition occurs both in the gaseous, liquid (rainfall) and particulate forms, each of these three categories should be measured. Sampling of these major compartments is as follows:

Atmospheric deposition, wet and dry; columns (3) and (4)

Frequency - monthly

Sampling period - 1 month

Equipment - An automated wet-fall/dry-fall sampler is used which is equivalent to the HASL sampler used in the U.S. National Atmospheric Deposition Program, manufactured by Aerochem Metrics. Similar samplers are the Sangamo Precipitation Collector Type A, used in the CANSAP study (Canadian) and FIN Collector manufactured by Pareleo Oy, Finland.

Surface waters; column (5)

Frequency - every 3 months

Equipment - bottles, grab samples, 1 liter each

Accumulation in animals, soil, litter, vegetation; column (6)

Frequency - once yearly

Atmospheric gasses; column (7)

Mercury

Frequency - monthly

Sampling period - 24 hours

Equipment - silver wool traps

Sulfur dioxide and ozone

Sampling period - continuous

Equipment - a continuous monitor reporting weekly averages

Atmospheric particulates; column (8)

Frequency - monthly

Sampling period - 10 days

Equipment - 0.45 micron filter, aspirated at 1 liter per minute

Product: Future questions concerning human health and terrestrial and aquatic productivity are related to the deposition and fate of a number of substances disbursed into the atmosphere through man's activities. While many of these materials are associated primarily with the industrialized nations, there is evidence that we are experiencing global transport through atmospheric processes. The list of materials included in the Level II program represents those which are thought to be most important with relation to human health and terrestrial and aquatic productivity. It is important to our understanding of atmospheric transport phenomena and the subsequent effect of these materials that we obtain a global picture of their deposition and their fate once they enter the biosphere. This level of monitoring provides measurements of atmospheric deposition, concentrations in surface water, and accumulation in terrestrial and aquatic biota.

Level III

Objective: To monitor trace metals and organics in all compartments.

Recommendations: In Level II those materials which are currently thought to be most important in considerations of human health and terrestrial and aquatic productivity were recommended for measurement in deposition and terrestrial and aquatic compartments. Where equipment and resources are available, it is recommended that, in addition, trace metals be measured and that several different organic compounds be monitored.

As stated, all Biosphere Reserves should carry out at least pH and conductivity measurements of rainfall and surface waters. It is strongly urged, however, since these measurements are only gross indicators of trends in changes of composition, that the Level II and III program should be carried out if at all possible. The measurements recommended at this level are being carried out in many parts of the world, particularly the industrialized nations because of the increased concern for atmospheric pollution and its consequences.

Frequency - See Level II

Product: As more information is gained concerning toxic organic materials, the list of organics will undoubtedly be expanded in the future. This information is critical if we are to be able to assess the potential for changes of productivity in the Biosphere Reserves over long periods of time, and to assess the potential for effects on human health.

Level II								
Level I								
			Atmospheric deposition				Atmospheric	
Measurement	Rainfall (1)	Surface waters (2)	Wet (rain) (3)	Dry (dust) (4)	Surface waters (5)	Accumulation-animals, soil, litter vegetation (6)	Gasses (7)	Particulates (8)
pH	X	X	X	X	X			
Cond.	X	X	X		X			
$SO_4^{=}$			X	X	X			
$PO_4^{\equiv}$			X	X	X			
Cl^-			X	X	X			
NO_3^-			X	X	X			
NH_4^+			X	X	X			
K^+			X	X	X			
Na^+			X	X	X			
Ca^{++}			X	X	X			
Mg^{++}			X	X	X			
Hg				X	X	X	X	X
Pb				X	X	X		X
Cd				X	X	X		X
As				X	X	X		X
SO_2							X	
O_3							X	
Level III								
Trace metals			X	X	X	X		X
TSP								X
Benzopyrene			X	X				
Cl hydrocarbons			X		X	X	X	

BIOLOGICAL

Level I

Object: To monitor biological characteristics of ecosystems with minimal use of equipment, minimal cost, and limited, trained personnel. To provide survey information which facilitates subsequent expansion of monitoring efforts to Level II.

Recommendations: To facilitate the referencing of localities which accompany data to be collected, a topographic map should be obtained at the outset. The object is to obtain the "best possible" map upon which the boundaries of the reserve can be marked. This should be reproduced at a scale which permits mapping of major landforms, rivers, streams, lakes, forests, grasslands, etc. It should include any obvious natural barriers or artificial barriers to the movements of animal populations or the propagation of plant populations. On additional maps, one per observation tour, points of reference, repeatedly used observation sites and species sightings should be recorded as precisely as possible. Summary maps, one per species, should be made and continuously updated, showing the distribution of individual sightings. Such maps are of critical long-term value in documenting species distribution and abundance, and are necessary for future population dynamics studies. Their contribution to impact analyses increases with time.

Photographic records of monitoring sites or observation routes and posts, aerial photographs support recorded observations and contribute to the development of more accurate biological maps. More importantly, photographs are likely to document diagnostic features of the habitat or its condition, not interpreted by untrained personnel and may serve as valuable historic references at a later date.

Field guides or other documentations of species common to the area, country or region should be obtained. Species sightings can then be recorded and checked against indigenous species. Observation lists contribute to an eventual checklist of fauna and flora of the reserve. Special notice should be made of species which are of potential economic, managerial or international significance. Such lists may already exist, but may also be derived from regional floras, faunal studies, monographs, or field surveys or collections. Lists of those species of special significance, such as those designated as rare, endangered, or threatened, those of special historical or cultural significance, those of economic importance, aesthetic appeal, or those that present special management problems are also desirable. This will help select key species as the subjects of population analyses in Level II.

Product:

1. initial species inventories upon which more detailed inventories can be conducted.
2. preliminary maps which aid in determining points of greatest species diversity and interaction, potentially fragile areas and potential sources of impact.

3. preliminary records which aid in determining the course of subsequent monitoring and analysis.

<u>Level II</u>

Object: to collect quantitative data necessary to develop long-term management plans, to study population dynamics and begin to integrate data contributing to the understanding of community structures and dynamics.

Level II requires specimen collection, marking and likely tracking. Specialized personnel with experience in field biology are desirable, these may include zoologists, botanists, or limnologists. Intensive coordinated teamwork during the field period would provide most of the data and analysis characterizing Level II.

Some management of data, analysis, and modeling is required at this level and should be developed with two major points in mind 1) that the system be designed with long-term objectives, and should be modifiable without loss of previous investments; and 2) that coordination between reserves particularly with others in similar habitats be maximized from the begining when research and analysis designs are being planned. This will facilitate eventual comparisons of data between reserves.

Recommendations: A map should be made detailing landforms, natural barriers and vegetation communities. Maps should be kept for each of the species chosen to be monitored outlining their distributions and abundances. This will provide an accessible pictorial reference of changes taking place in species distribution and abundance. It will also provide local coordinates for quantification of distribution. Relationships should be explored between observed population distributions, dispersion and abundance and geophysical, chemical and demographic features of the reserve. In addition to providing first qualitative summaries of processes in the communities this will enable scientists to select directions and priorities for emphasis in subsequent research and monitoring. Regular monitoring sites and transects having been established will provide means of extracting additional data quantitatively from geographical localities. Aerial photography will support both the mapping efforts and the data collection efforts, particularly on permanent plots.

Species inventories, continued from Level I, should lead to the production of a complete species checklist. Key species should become the focus of intense monitoring efforts. Included in this selection of species should be, rare and endangered species, some endemics, species which are known environmental indicators as well as species of particular importance to man. It may be feasible in some habitats such as arid lands to monitor most, if not all, species contained in the reserve, however similar objectives in most other tropical or temperate habitats are unrealistic.

Concurrent to these efforts, other measurements should be made which contribute to the analysis and understanding of long-term population dynamics for the key species. Special efforts must be made to develop long-term research and monitoring designs with specific objectives in view. These must maximize continuity and consistency in monitoring procedures and analysis within and between reserves.

If funds and facilities are available, attempts should be made to develop descriptive models of the key species populations. Attempts at simulation and predictions of short and long-term population responses to internal and external changes favor the development of sound management plans. Simultaneously, the task of measuring community dynamics can begin to be approached.

Product:

1. a completed species checklist
2. a detailed map of communities including aerial photographs
3. a distribution map for each of the key species reflecting abundance and dispersion including movements

4. transcects and specific monitoring sites are established and data recorded regularly
5. measurements are made of population dynamics in key species and population models are developed
6. data are made available, critical for Level III to measure dynamics of communities and the long-term effects of impact.

Level III

Object: to integrate population models into community models; to integrate biological data with those of geophysical, chemical and demographic monitoring efforts. This will lead to the development and continuing enhancement (by ongoing monitoring) of management systems and impact evaluations for the reserves.

Recommendations: This step requires personnel aquainted with ecosystems modeling and access to computer facilities. Apart from the continuation of monitoring activities, most of the work comprises analysis of accumulated data and the development of simulation models.

Alternative models are developed based upon different selections of variables which aid in strengthening or testing predictions of population fluctuations, community changes and responses to impact. This is done in coordination with geophysical, chemical and demographic monitoring teams.

The activities of Levels I and II should be maintained in Level III so that the models of Level III can be adjusted in time.

Product:

1. accurate interdisciplinary community descriptions and alternative sets of models describing and predicting dynamics of communities
2. integrated impact response models
3. ongoing testing of models with new data collected regularly
4. management plans for reserves, plans which have a sound base and which are easily modifiable
5. a data storage retrieval and analysis system which is consistent in format and permits coordinated studies with other reserves.

BIOLOGICAL

	I	II	III
EVENT RECORD*	x	x	x
MAPS OF BIOLOGICAL INVENTORY			
On existing available base map, plot major landforms; open areas, forests, rivers, streams, lakes, zoogenic features (wallows scrapings), etc.	x		
On existing available base map, plot major potential sources of impact, major population centers or human use areas	x		
Develop map of major communities (qualitative assessment)		x	
Species distribution and population distribution maps		x	
PHOTOGRAPHY			
General habitat records	x		
Aerial 100m		x	
Transects		x	
SPECIES INVENTORIES			
Generate checklist by checking species off of existing guide, key species first	x		
Complete checklist of species		x	
Designate which species are: rare, endangered, of economic importance or are exotic		x	
POPULATIONS AND ABUNDANCE			
Population dynamics			
measurements		x	
dispersal			
dispersion including movements			
population size			
population density			
age structure			
growth/recruitment/productivity			
regulation			
fluctuations			
integration of population dynamics		x	
COMMUNITY DYNAMICS			
qualitative descriptions		x	
quantitative descriptions			
integration of population dynamics			x
trophic relations		x	
changes in species composition		x	
integration of events into community dynamics			x
IMPACT RELATIONSHIPS			
qualitative		x	
quantitative and integration into community dynamics			x

MODELS

generation of population models	x
integration of population models into community models	x
refinement of community models and generation of alternative models	x

*An event record is the detailed record of unique or unusual occurrences and notable for their rarity or intensity, which might be expected to significantly affect an ecosystem.

GEO-PHYSICAL

Level I

Object: To develop basic information necessary to characterize Biosphere Reserve sites and, more importantly, establish reference materials important to research and monitoring projects in other categories.

Recommendations: Event recording provides a record of those unique or significant occurrences which can be characterized as having an observable physiographic response. Event recordings include the time, place, size intensity, etc. of any defined parameter impinging on a system in a recognizable way, such as seasonal events (snow-pack, dust storms, floods, windthrow, etc.) but also importantly, unique, unusual or catastrophic geological or meteorological events (vis, floods, earthquakes, volcanic eruptions, erosion). Records of daily maximum and minimum air temperatures, precipitation events, characterizing atmospheric condition, and the development of maps delimiting the nature of the Biosphere Reserve resource are essential. Geologic maps emphasizing structural and surficial features are generally available in some scale and should be used. Common scale maps should be chosen based on availability with the exception of standardized scales at Level II. Aerial photos and Landsat data should be used with national statistics, published material, or new data to identify and measure specific features. The location, size, and number of streams, lakes, wetlands, and ground water supplies should be mapped from available information and field checked. Major drainages should be given particular attention for future use as major possible representative study sites in the biological monitoring.

Product: Mapping activities, combined with climatic data support vegetation mapping activities and provide initial data for habitat classification determinations and support the establishment of sample sites, permanent plots, and aquatic studies.

Level II

Object: To provide additional data required to assess the dominant processes which characterize a site or area. These data are intended to reveal gross trends and provide a more detailed characterization of the site for comparative analyses with other sites against which to measure perceived anthropogenic change for special correlative studies.

Recommendations: Level II activities require additional standardized mapping (1:24,000) to support habitat and ecosystem studies and to provide the materials for the base mapping scale in most comparative analyses. Soil analyses to determine organic content, infiltration rates, cation exchange capacity, and other parameters are particularly supportive of the other monitoring categories and should be of high priority.

Atmospheric monitoring methods and equipment should be compatible with existing networks such as those of the World Meteorological Organization.

Product: Tabular data collection at Level II further characterizes those physical, meteorologic, hydrologic, geologic variables which can assist with the assessment or analysis of species community and habitat response to the atmosphere and lithosphere. The data also permits the qualification of results from chemical monitoring. Hypotheses can be formed to carry out certain Level III studies.

Level III

Object: To establish a detailed data base which separates random physical changes from predictable occurrences analyses of local, regional or global change. To isolate physical aspects of the site which may be considered for their value as indicators.

Recommendations: Fully automated recording stations are necessary to provide frequent measurements of meteorological and hydrological parameters on a regular basis. For remote sites, transmission of data to satellites and back to a central point is achievable without great difficulty and should be considered when appropriate, to reduce personnel costs. Parameters of clear global interest (CO_2, ionizing radiation, etc.) are monitored to determine the degree and extent of their role in the natural environment. Regional and local issues (groundwater depletion, loss of forestland, desertification, etc.) are equally important and should be identified at the earliest feasible time.

Product: Activities at Level III establish specialized maps, detailed geochemical and hydrologic monitoring with continuous automated stations. It also provides detailed and closely spaced data sets to support quantitative impact analyses as related to community dynamics and processes of change. A WMO weather station establishes links between Biosphere Reserves and a global network of stations gathering similar data to monitor meterological trends.

GEO-PHYSICAL

	I	II	III
INVENTORY			
Event occurrence - historic records	x		
Imagery			
satellite	x		
aerial photography			
1:100,000	x		
1:24,000		x	
GEOLOGY & GEOLOGICAL MAPPING			
Reconnaissance level			
geologic	x		
topographic	x		
soils	x		
Geologic Map Scale			
1:24,000 or the equivalant		x	
Special Purpose Maps			
(geol. hazards) flood plain maps			x
channel characteristics			x
Physical Geology and Minerology			
soil analyses		x	
organic content		x	
water holding characteristics		x	
mechanical analysis		x	
physical analysis		x	
water erodibility (index)		x	
infiltration rate		x	
soil productivity (composite index)		x	
cation exchange		x	
sediment transport		x	
dissolved		x	
suspended		x	
bed load			x
mineralogy		x	
HYDROLOGY			
Watershed maps	x		
recon	x		
map scale (1:24,000)		x	
Special purpose			
groundwater (water table)		x	
Inventory (description)	x		
streams	x		
lakes	x		
wetlands	x		
groundwater	x		

Physical parameters			
temperature (max. - min.)		x	
stream (monthly)		x	
lake (seasonal)		x	
wetlands (seasonal)		x	
groundwater (annually)		x	
turbidity (sechi disk)			
streams (episodic)		x	
lake		x	
wetlands		x	
discharge (recording gauges)			
streams		x	
lake (in and out flows)		x	
wetlands			
stage (recording)			
streams	x		
lake	x		
automatic gauging (temperature, discharge stage)			x
METEOROLOGY			
Precipitation			
monthly total	x		
weekly, daily totals		x	
recording guages along prec. gradient			x
Air Temperature			
daily	x		
Atmospheric properties (wind speed, direction, humidity, etc.			
closest available station and stations	x		
standard station on site (to include short wave isolation, recording hygrothermograph)		x	
CO_2 Monitor			x
Ionizing radiation-background levels			x
WMO Recording Station			x

ANTHROPOLOGICAL

Level I

Object: To document direct human related effects on natural ecosystems in Biosphere Reserves, and to identify methods which can be used to minimize negative impacts.

Recommendations: Development of specialized land use maps delimiting the boundaries of human use activities such as slash and burn, gathering of firewood, and settlements is valuable and useful information in determining location of human pressures and as qualifiers of data gathered in other categories. Ownership and economic bases are related to the types of impacts which might be expected in the future, and should be documented in precise terms using existing available data. Research and training activities and facilities should be documented including citations of published literature and available instruments. Public facilities serving human populations should be located on land use maps. Reliance by economic species such as cattle on the Biosphere Reserve for forage should be identified at this stage by type and number of herds.

Product: An account of specific aspects of human organization and activity which need to be accounted for in the other monitoring categories and will allow the separation of localized and regional or global phenomena. A preliminary assessment is also made of resources available to work with, allowing maximum utilization.

Level II

Object: To begin quantifying economic uses of Biosphere Reserves and aspects of human populations which can be anticipated to have a dominant effect on the site. To identify goals and priorities which might form a management plan.

Recommendations: Many countries are reaching the limits of firewood availibility for growing populations. Other countries have an increasing demand for grazing lands at a time when such areas are becoming scarce. It is recommended that efforts be made at Level II to begin correlating relevant factors such as population size and demand for fuel with availibility as determined in the biological monitoring effort. If the site serves as a primary food source, serious attention should be given on that basis.

Product: The establishment of relationships between human use or consumption and biological productivity. The quantification of economic productivity, and the yield or sustainability of natural ecosystems.

Level III

Object: To develop a management plan for the Biosphere Reserve.

Recommendations: Identify and fill necessary information gaps recording inputs into the site such as humans, livestock, fertilizers, etc. and outputs such as migrations, animal reduction, yield/area for selected economic factors. Develop a sound plan for human activities on the Biosphere Reserve site based in part on findings in the level one and two programs of the other monitoring categories.

ANTHROPOLOGICAL

	I	II	III
EVENT RECORD*	x	x	x
MAPS			
Settlements, use areas	x		
HUMAN ACTIVITIES & BENETITS			
Identification (farming, grazing, forestry, hunting, recreation, etc.)	x		
Quantification (yield/acre, board feet, tons food/capita)		x	x
OWNERSHIP			
Public, private (hectares)	x		
Area by owner and size class		x	
Number of owners		x	
DEMOGRAPHY			
Human population (#) residents, visitors, and neighbors	x		
Age/sex distribution		x	
Diet/health (incidence of disease)		x	
Educational Levels	x		
Housing (type, location)		x	
Per capita income and source			x
Nationality of visitors			x
ANIMALS			
Livestock (# of individuals)		x	
(species, # of groups, herds)	x		
Pets and other domestic			
Uses of commerical species			x
LEGAL			
Acts, regulations, policies (affecting reserve)	x		
Management activities and priorities (type, frequency, extent)		x	
Management Plan			x
EDUCATION			
Research and training activities			
type	x		
facilities, budget, staff		x	
DEVELOPMENT			
Public facilities (labs, hospitals)	x		
Services (water, electricity, health)	x		
Additional quantification		x	

*Recording and where possible quantifying unique or unusual anthropological events (migrations, effects of drought, epidemic, shift in fertility).

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Foreign Participants - International Workshop
on Long-Term Ecological Monitoring in Biosphere Reserves
October 20-28, 1978 U.S.A.

Emmanuel O.A. Asibey
Chief, Game & Wildlife Officer
Department of Game & Wildlife
P.O. Box M 239
Accra, GHANA

John A. Carruthers
% Patricia Roberts-Pichette
Canadian MAB Programme
Liaison & Coordination Directorate
Environment Canada
Ottawa, Ontario KIA OH3 CANADA

Pedro Reyes-Castillo
Instituto de Ecologia
Nuevo Bosque de Chapultepec
Apartado Postal 18-845
MEXICO, 18, D.F.

*Lyucienna M. Filippova
Head of Department
Institute of Applies Geophysics
Hydromet
Moscow, USSR

Rawdon Goodier
Nature Conservancy Council
Scottish Headquarters
12 Hope Terrace
Edinburgh, SCOTLAND EH9 2AS

*Pyotr Gunin
Senior Scientist
Institute of Evolutionary Morphology
& Ecology of Animals
USSR Academy of Animals
Moscow, USSR

*Negotiating team US-USSR Bilateral Agreement (02.05041)

Michael D. Gwynne
Senior Scientific Affairs Officer
UNEP, GEMS
P.O. Box 30552
Nairobi, KENYA

David N. Kinyanjui
National Environment Secretariat
Office of the President
P.O. Box 30510
Nairobi, KENYA

Guillermo W. Mann
Corporacion Nacional Forestal
Avda. Bulnes 285 Oficina 401
Santiago, CHILE

Nina T. Nechayeva
Academy of Sciences
Turkman USSR Desert Institute
744000 Ashkabad, USSR

Benght Nihlgaard
Department of Plant Ecology
University of Lund
Helgonavaegen 5, S 22362
Lund, SWEDEN

*Felix Y. Rovinsky
Head of Department
Institute of Applied Geophysics
Hydromet
Moscow, USSR

*S.M. Semenov
Senior Scientist
Institute of Applied Geophysics
Hydromet
Moscow, USSR

Vladimir Smirnov
Chief Administrator
USSR Man and the Biosphere Programme
Aven. 9 Kalinin
Moscow, USSR

Yuriy Starikov
Expert
Soviet Secretariat for US-USSR
Environmental Agreement
Moscow, USSR

H.L. Teller
Division of Ecological Sciences
UNESCO
7 Place de Fontenoy
75700 Paris, FRANCE

U.S. Participants - International Workshop
on Long-Term Ecological Monitoring in Biosphere Reserves
October 20-28, 1978 U.S.A.

Stanley I. Auerbach
Director, Environmental Sciences Division
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

Carl Berntsen
Director, Office of Timber Management Research
P.O. Box 2417, 811 RPE
U.S. Forest Service
Washington, D.C 20013

Susan P. Bratton
Coordinator, Uplands Research Laboratory
Great Smoky Mountains National Park
Gatlinburg, TN 37738

Robert L. Burgess
Environmental Sciences Division
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37916

Edward Clebsch
Ecology Program
University of Tennessee
Knoxville, TN 37916

Boyd Evison
Superintendent, Great Smoky Mountains National Park
Gatlinburg, TN 37738

Jerry F. Franklin
Project Leader, US-USSR Bilateral Agreement on Biosphere Reserves
Forestry Sciences Lab
3200 Jefferson Way
Corvallis, OR 97331

James H. Gibson
Natural Resources Ecology Lab
Colorado State University
Ft. Collins, CO 80523

Vernon C. Gilbert
Chief, Natural History Division
National Park Service
Department of the Interior
Washington, D.C. 20240

Raymond Herrmann , Chief
Air & Water Resources Division
National Park Service
Department of the Interior
Washington, D.C. 20240

Alexis J. Hoskins
Science Consultant
Committee on Science & Technology
2319 Rayburn Building
Washington, D.C. 20515

Robert Joyce
Data Services Branch
Tennessee Valley Authority
Chattanooga, TN 37401

Donald R. King
Director, Office of Environmental Affairs (OES/ENP/EN)
Department of State, Room 7822
Washington, D.C. 20520

Gary L. Larson
Coordinator, Uplands Research Laboratory
Great Smoky Mountains National Park
Gatlinburg, TN 37738

George H. Lauff
Director, Kellogg Biological Station
Michigan State University
Hickory Corners, MI 49060

Timothy Lynch
Legislation Assistant to Honorable George E. Brown
2342 Rayburn Building
Washington, D.C. 20515

Edward Mainland
Office of Environmental Affairs (OES/ENP/EN)
Department of State
Washington, D.C. 20520

Oscar J. Olson
Executive Director, U.S. MAB Committee
National Commission for UNESCO
Department of State
Washington, D.C. 20520

William Parkhurst
Air Quality Branch
Tennessee Valley Authority
Chattanooga, TN 37401

Neil J. Reid
Regional Chief Scientist
National Park Service
P O. Box 25287
Denver, CO 80225

Paul G. Risser
Oklahoma Biological Survey
University of Oklahoma
770 Van Vleet Oval-Room 6
Norman, OK 73019

Charles J. Robinove
EROS Program, USGS
1925 Newton Square, East
Reston, VA 22090

Raisa Scriabine
Forum International
1028 Connecticut Avenue, N.W.
Washington, D.C. 20036

Wayne T. Swank
Coweeta Hydrological Laboratory
P.O. Box 601
Franklin, NC 28734

Lloyd W. Swift
Coweeta Hydrological Laboratory
P.O. Box 601
Franklin, NC 28734

Jeffrey B. Tschirley
Natural History Division
National Park Service
Department of the Interior
Washington, D.C. 20240

Julie A. Watts
Environmental Sciences Division
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

G. Bruce Wiersma
Monitoring Systems Research and Development Division
Box 15027
Environmental Protection Agency
Las Vegas, NV 89114

REPORT OF MAB-8 ACTIVITIES

Foreign participants gathered at the Department of State in Washington, D.C. at 10:00 am on Friday, October 20, 1978 for briefings on the overall U.S. MAB Programme and to inform the group of MAB-8 activities taking place in their country.

Mr. Reyes-Castillo of Mexico reported that the two Biosphere Reserves in his country have been designed through a legislative process and thus have a degree of legal protection. He also indicated that in Mexico the long and short term success of a Biosphere Reserve is to a large extent determined by the extent to which the designation process begins at the grass roots level and works up, gradually answering the many questions that are raised during the process by users of the land, land managers, and politicians rather than simply designating it without consultation. Mr. Castillo reported on a cooperative project between Mexico and the United States, involving La Michilia and Beaver Creek Biosphere Reserves, in which scientists are working together to solve land management problems and investigate common research areas.

Mr. Carruthers of Canada reported that the canadian MAB-8 Directorate is preparing to propose Biosphere Reserve status for Waterton Lakes, which borders Glacier National Park, a U.S. Biosphere Reserve. If designated these would be the first adjoining international Biosphere Reserves and would provide excellent opportunities for joint projects. Mr. Carruthers also referred to a 1977 publication, Environmental Monitoring in Canada, which provides a brief description and details on relevant monitoring and research activities in Canada. He also indicated that ecological research and monitoring programs have suffered from a recent budget cutback.

Mr. Mann reported that Chile has submitted nominations for two additional Biosphere Reserves (there are currently three designated) for consideration by the MAB International Coordinating Council (ICC). The existing Chilean Biosphere Reserves are located in National Parks which have legal protection and include tropical forest, subtropical forest, and steppe brush biomes.

Mr. Nihlgaard stated that, although Sweden has not designated Biosphere Reserves, they are active in programs relevant to long-term monitoring. He described wide ranging research projects in coniferous forests, as well as monitoring of acid precipitation and heavy metals. The Swedish water monitoring program concentrates primarily on chemical elements considered to be of regional importance. A long-term terrestrial monitoring program currently has 19 observation sites which monitor a spectrum of land use impacts on forested, agricultural, and urban lands.

Mr. Asibey of Ghana described the use of primates as environmental indicators. Some preliminary monitoring has been done in Ghana on the ecological effects of logging and firewood collection. Mr. Asibey indicated that a monitoring framework exists in his country, but that additional funds are needed for its implementation.

Mr. Kinyanjui informed the workshop that Kenya has established two Biosphere Reserves, representative of the floral & faunal diversity of the country. The Kenyan government is monitoring the ecosystem dynamics of the areas. It was noted that due to a new environmental protection law, Kenya is able to exert stronger control over the use of its resources.

Mr. Goodier reported that the United Kingdom currently has 13 Biosphere Reserves and is attempting to ensure additional Biosphere Reserves will fill gaps in the representation of the country's biome types. There is considerable interest in monitoring in the United Kingdom. On the biological side, wild deer populations are receiving particular attention.

Ms. Filippova and Mssrs. Gunin Rovinsky, Semenov and Starikov made up the Soviet team which discussed a long-term bilateral Biosphere Reserve monitoring program with U.S. scientists and participated in part of the workshop. Ms. Nechayeva and Mr. Smirnov, representing the USSR at the workshop, reported that seven USSR Biosphere Reserves have been approved to date. Maximum and minimum Biosphere Reserve monitoring programs are being devised for both natural and disturbed systems, and for various trophic levels within a system.

Mr. Teller, representing the UNESCO/MAB Secretariat urged member states with Biosphere Reserves to join with appropriate international organizations in developing a long-term monitoring program. By balancing issues of global concern with those of regional or national interest, individual Biosphere Reserves could participate in an international program according to their interests and resources. Local monitoring programs may well wish to emphasize processes such as nutrient cycling, energy flow, the hydrological cycle, and pollutant pathways, and an international program must be sufficiently flexible to allow such emphasis.

Mr. Gwynne, representing the Global Environmental Monitoring System (GEMS) of UNEP, reviewed the development of GEMS from its initiation in 1975, when it began its role as catalyst and coordinator for global environmental monitoring issues. Although some aspects of terrestrial ecosystem monitoring has not received early priority, it is now felt that opportunities for greater interaction between GEMS and MAB exist.