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.

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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.
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 databases.

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 Meteorological 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,
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) re-
ported 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 environment 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. 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.
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<th>Surface waters (5)</th>
<th>Accumulation-animals, soil, litter vegetation (6)</th>
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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 and 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.

Level II

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 beginning 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. transects 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 acquainted 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.
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
- integration of population models into community models
- refinement of community models and generation of alternative models

*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 (CO₂, 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 meteorological trends.
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Scale</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INVENTORY</strong></td>
<td>Event occurrence - historic records</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Imagery</td>
<td>satellite</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>aerial photography</td>
<td>1:100,000</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>1:24,000</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><strong>GEOLOGY &amp; GEOLOGICAL MAPPING</strong></td>
<td>Reconnaissance level</td>
<td></td>
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<tr>
<td>geologic</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>topographic</td>
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</tr>
<tr>
<td>soils</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Geologic Map Scale</td>
<td>1:24,000 or the equivalent</td>
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<td>x</td>
</tr>
<tr>
<td>Special Purpose Maps</td>
<td>(geol. hazards) flood plain maps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>channel characteristics</td>
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<td></td>
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<tr>
<td>Physical Geology and Minerology</td>
<td>soil analyses</td>
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<td>x</td>
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<tr>
<td>organic content</td>
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<td></td>
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</tr>
<tr>
<td>water holding characteristics</td>
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<td></td>
<td>x</td>
</tr>
<tr>
<td>mechanical analysis</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>physical analysis</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>water erodibility (index)</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>infiltration rate</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>soil productivity (composite index)</td>
<td></td>
<td></td>
<td>x</td>
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<tr>
<td>cation exchange</td>
<td></td>
<td></td>
<td>x</td>
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<tr>
<td>sediment transport</td>
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<td>x</td>
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<td>dissolved</td>
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<td>x</td>
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<tr>
<td>suspended</td>
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<tr>
<td>bed load</td>
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<tr>
<td>mineralogy</td>
<td></td>
<td></td>
<td>x</td>
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<tr>
<td><strong>HYDROLOGY</strong></td>
<td>Watershed maps</td>
<td></td>
<td>x</td>
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<tr>
<td>recon</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>map scale (1:24,000)</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Special purpose</td>
<td>groundwater (water table)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Inventory (description)</td>
<td>streams</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>lakes</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>wetlands</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>groundwater</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
Physical parameters

- temperature (max. - min.)
- stream (monthly)
- lake (seasonal)
- wetlands (seasonal)
- groundwater (annually)
- turbidity (sechi disk)
- streams (episodic)
- lake
- wetlands
- discharge (recording gauges)
- streams
- lake (in and out flows)
- wetlands
- stage (recording)
- streams
- lake
- automatic gauging
  (temperature, discharge stage)

METEOROLOGY

- Precipitation
  - monthly total
  - weekly, daily totals
- Air Temperature
  - daily
- Atmospheric properties
  - wind speed, direction, humidity, etc.
  - closest available station and stations
  - standard station on site (to include short wave isolation, recording hygrothermograph)
- CO2 Monitor
- Ionizing radiation - background levels
- WMO Recording Station
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 availability 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 availability 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

<table>
<thead>
<tr>
<th>EVENT RECORD*</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>x</td>
<td>x</td>
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<table>
<thead>
<tr>
<th>MAPS</th>
<th>I</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Settlements, use areas</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HUMAN ACTIVITIES &amp; BENEFITS</th>
<th>I</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification (farming, grazing, forestry, hunting, recreation, etc.)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Quantification (yield/acre, board feet, tons food/capita)</td>
<td></td>
<td>x</td>
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<table>
<thead>
<tr>
<th>OWNERSHIP</th>
<th>I</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Public, private (hectares)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Area by owner and size class</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Number of owners</td>
<td></td>
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<table>
<thead>
<tr>
<th>DEMOGRAPHY</th>
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<tbody>
<tr>
<td>Human population (#) residents, visitors, and neighbors</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Age/sex distribution</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Diet/health (incidence of disease)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Educational Levels</td>
<td></td>
<td>x</td>
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<tr>
<td>Housing (type, location)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Per capita income and source</td>
<td></td>
<td>x</td>
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<tr>
<td>Nationality of visitors</td>
<td></td>
<td>x</td>
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<table>
<thead>
<tr>
<th>ANIMALS</th>
<th>I</th>
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<tbody>
<tr>
<td>Livestock (# of individuals)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>(species, # of groups, herds)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Pets and other domestic uses of commercial species</td>
<td></td>
<td>x</td>
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</table>

<table>
<thead>
<tr>
<th>LEGAL</th>
<th>I</th>
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</thead>
<tbody>
<tr>
<td>Acts, regulations, policies (affecting reserve)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Management activities and priorities (type, frequency, extent)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Management Plan</td>
<td></td>
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<table>
<thead>
<tr>
<th>EDUCATION</th>
<th>I</th>
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<tbody>
<tr>
<td>Research and training activities</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>type</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>facilities, budget, staff</td>
<td></td>
<td>x</td>
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</table>

<table>
<thead>
<tr>
<th>DEVELOPMENT</th>
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</thead>
<tbody>
<tr>
<td>Public facilities (labs, hospitals)</td>
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<td>x</td>
</tr>
<tr>
<td>Services (water, electricity, health)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Additional quantification</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

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


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

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October 20-28, 1978, U.S.A.

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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 L. 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.