United States Department of the Interior

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IN REPLY REFER TO:

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Memorandum

To: WASO Associate Directors, Regional Directors, and All Site Managers

From: Associate Director, Natural Resources

Subject: Draft Inventorying and Monitoring Standards and Guidelines

Reply Due: February 1, 1988

Copies of the Draft Standards and Guidelines for Natural Resources Inventorying and Monitoring are transmitted for review and comment.

References for the most up-to-date procedures and methods in inventorying and monitoring are of particular importance for completion of the last columns of the sections on Biological I&M and Geophysical I&M and your recommendations are requested.

Comments are due in Washington by February 1, 1988 in order to complete the Standards and Guidelines for distribution on April 1, 1988. Comments and recommendations will be compiled and incorporated into the final report by the Office of the Senior Scientist. If you have any questions, or wish to discuss the draft standards and guidelines or any other topic which bears on this matter, please write or telephone:

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Attachment

DRAFT

STANDARDS AND GUIDELINES FOR NATURAL RESOURCES INVENTORYING AND MONITORING

U.S. Department of the Interior
National Park Service
December 1987

ACKNOWLEDGEMENTS

This inventorying and monitoring document was prepared on the foundation furnished by the Man and the Biosphere Program's "Long-term Ecological Monitoring in Biosphere Reserves," 1979, a document written by a panel of international experts in meetings sponsored by this office in 1978. Its philosophy was derived from that stated in the document, "Natural Resources Inventory and Monitoring Initiative," May 1987/revised July 1987. It was written by Ray Herrmann, Robert Stottlemeyer, Philip Wandra, and Albert Greene, Jr. Advice and counsel were offered by a number of others, including Gary Davis, Boyd Evison, David Graber, and Roland Wauer. Editing was by Audrey Dixon.

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INTRODUCTION

Policy

The Inventorying & Monitoring (I&M) Policy Statement for NPS stated in the Natural Resources Inventory & Monitoring Initiative of May 1987 (revised July 1987), that "It is the policy of the National Park Service to assemble baseline inventory data describing the natural resources under its stewardship, and to monitor those resources forever - to detect or predict changes that may require intervention, and to provide reference points to which comparisons with other, more altered parts of the home of mankind may be made."

Natural resource inventorying is, by definition, "the process of acquiring, managing, and analyzing information on park resources, including the presence, distribution, and condition of plants, animals, soils, water, air, natural features, biotic communities, and natural processes.

"Long-term monitoring is the systematic collection and analysis of those resource data at regular intervals, in perpetuity, to predict or detect natural and human-induced changes, and to provide the basis for appropriate management response."

Purpose

These guidelines are for the purpose of listing the kinds and frequencies of activities that may take place in national parks in implementing an Inventorying and Monitoring (I&M) program. This is not a handbook on "how to do it," but a guide to be used by personnel who have professional training and knowledge of the subject.

Philosophy

Units of the National Park System are diverse and have individual resource information requirements. However, all parks have common minimal information needs. Adequate I&M guidelines must (1) list and provide standards for these "Level of Effort I" information needs, and (2) provide minimal standards for subsequent, more intensive data collection. The I&M program is not intended to answer each individual resource question, but to provide a level of knowledge Servicewide that will allow more directed future study, problem analysis, and problem solution.

The NPS National Resource Inventory and Monitoring Initiative (July 1987) provides the overview leading to these guidelines which define a "minimal" working program. What follows is based upon ongoing monitoring and inventorying programs both within and outside NPS, and largely relies on past experience in this effort to produce systematic Servicewide data collection.

The issues (questions) driving long-term I&M and research programs can be viewed as having differing scales: global, regional and local. The data sets to be filled, although highly variable over time, are nonetheless site specific. Thus, all areas will fit into a data collection scheme that will provide park management the level of information needed to understand, interpret, and conserve park resources.

This approach requires that we observe and document the "elements of change" for park systems/ecosystems in a manner adequate to interpret and analyze the cause of change. To accomplish this we must periodically inventory biotic and abiotic elements, continuously monitor important ecosystem processes (e.g., human-induced land use change, flood, fire, wind, earthquakes, volcano eruptions, infestations, biogeochemical cycle changes, etc.). Thus, step one of the I&M process is to document the status of each park's present inventory relative to the minimal needs (Level of Effort I) of I&M. The first I&M priority will be to complete Level of Effort I inventories. This inventory is the minimal data base which subsequent, more intensive data sets can complement.

The monitoring program for each area can only be finalized when based upon a close analysis of the "completed" inventory of existing data sets that relate directly and indirectly to a park. This need invariably causes uncertainty about the scale of such an undertaking. We anticipate that national technical coordination of program development will lessen these difficulties and assist the regions and park units in finding and developing the resources required for initial I&M activities.

A frequent criticism of I&M efforts is that data are collected for data's sake and that there are no clear data uses. A coordinated effort which builds upon a common data base and applied minimal standards for subsequent data collection will define the role of collected data, and make all data bases, no matter how detailed, more responsive to park management needs.

COMMON ELEMENTS AND GOALS

As we begin to review the parks with ongoing I&M activities and suggested by the regions (NPS 1987), we can establish a number of common elements and goals.

Likely, the present programs are very disparate as they are driven by a number of overlapping management concerns. They can, however, be presented as representative of programs being driven by a number of related global, regional, and local issues (viz. atmospheric deposition, population distributions and relationships, and resource integrity) which have resulted in a set of site specific measurements. Multiple park natural resources monitoring programs identified as now having a set of uniform data collection requirements are limited, but examples include:

1. National Acid Precipitation Assessment Program (NSPSP),
2. National Atmospheric Deposition Program (NADP),
3. Visibility,
4. Dry deposition, and
5. Firepro.

A review of ongoing activities in these programs will provide insight for improving these suggested guidelines.

Implementation

As a first step to implementation of Servicewide guidelines and standards for Inventorying and Monitoring (I&M) in the parks, a three step process is in place:

1. A first iteration of I&M guidelines and standards (protocols);
2. Systematic assessment of existing NPS I&M activities;
3. A phased implementation plan for parks, including minimum levels of expected unit participation.

Each of these necessary steps, progressing in series and in parallel to develop Servicewide and outside support for this initiative, are laid out in this protocol/proposal document.

CHEMICAL INVENTORYING AND MONITORING

Inventorying and monitoring (I&M) of chemical elements and compounds present in parks establishes baselines and scales of comparison through examination and identification of specific nutrients and pollutants. This aspect of I&M is closely tied to the other categories in both the minimum level of effort program and the other levels of effort.

Chemical I&M focuses on five sections of the environment, with the goals being to measure nutrient input and status, to detect undesirable substances and their transport (long-range and within a system), and to identify ecosystems and human health. The I&M of natural substances and the detecting of pollutants 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 later. Sampling and sample storage, chemical analysis, and data interpretation should be standardized. In practice, this is difficult to achieve. Therefore, a minimum quality control program of participating laboratories through the analysis of replicates and standard samples is desirable.

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. The correlations will allow inferences to be made as to the magnitude of inputs of substances from the atmosphere and the effect on surface waters.

LEVEL OF EFFORT I

Objectives:

...At remote parks and other locations where equipment and personnel are not readily available to carry out a wider ranger of I&M:

...To take conductivity and pH measurements in rainfall and surface waters.

...To

Recommendations:

Products:

LEVEL OF EFFORT II:

Objective:

...To measure, at regular intervals, selected cations and anions in atmospheric deposition, surface waters, accumulations in animals, soil, litter and vegetation, and atmospheric gasses and particulates.

Recommendations:

This Level of Effort's information from surveys establishes baselines in parameters, with the intention of identifying those of possible regional or global significance.

As 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 to be as follows:

1. Atmospheric deposition, wet and dry: (See columns 3 and 4)
   a. Frequency: Once a month.
   b. Sampling period: One month.
   c. Equipment needed: An automated wet-fall/dry-fall sampler is used; it 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.

2. Surface waters (See column 5.)
   a. Frequency: Once every three months.
   b. Equipment needed: Bottles, grab samples, 1 liter each.

3. Accumulations in animals, soil, litter, vegetation: (See column 6.)
   a. Frequency: Once yearly.

4. Atmospheric gasses: (See column 7.)
   a. Mercury:
      (1) Frequency: Once per month.
      (2) Sampling period: 24 hours.
      (3) Equipment needed: Silver wool traps.
   b. Nitrogen oxides
   c. Sulfur dioxide and ozone:
      (1) Sampling period: Continuously.
      (2) Equipment needed: A continuous montiro reporting weekly averages.

d. Atmospheric particulates: (See column 8.)
   (1) Frequency: Once per month.
   (2) Sampling period: 10 days.
   (3) Equipment needed: 0.45 micron filter, aspirated at 1 liter per minute.

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 human 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 of Effort II program represents those that are thought to be most important with relation to human health, terrestrial and aquatic productivity, or indicative of pollutants' transport. 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.

Products:

1. Event records.
2. Data collected as listed in Recommendations, above, and on chart, for surface waters, atmospheric gasses, etc.
3. Maps to indicate where unusual conditions exist.

LEVEL OF EFFORT III:

Objective:

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

Recommendations:

In Level of Effort II, those materials currently thought to be most important to 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 the Level of Effort III, trace metals be measured, and that several different organic compounds be monitored.

As stated earlier, all National Park areas should carry out at least pH and conductivity measurements of rainfall and surface waters and establish baseline data. As these measurements are only gross indicators of trends in changes of composition, however, it is strongly urged that Levels of Effort II and III be carried out also. The measurements recommended at this level are being carried out in many parts of the world already, particularly in industrialized nations, because of the increased concern for atmospheric pollution and its consequences. The frequency of the inventorying and monitoring is to be as in Level of Effort II.

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

CHEMICAL INVENTORYING AND MONITORING

LEVEL OF EFFORT I (Reference: Wiersma, 1985) (On park and nearby sites)

Elements To Be Measured	Rainfall (1)	Surface Waters (2)	Atmospheric Deposition		Surface Waters (5)
			Wet (Rain) (3)	Dry (Dust) (4)	
pH	x	x	x	x	x
Conductivity.	x	x	x		x
$SO_4^{=}$.....			x	x	x
$PO_4^{=}$.....			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

LEVEL OF EFFORT II (Reference: Wiersma, EPA, ASTM) (Continuous I&M)

Elements To Be Measured	Accumulation in Animals, Soil, Litter, Vegetation (6)	Atmospheric	
		Gasses (7)	Particulates (8)
Hg	x	x	x

LEVEL OF EFFORT II (Reference: Wiersma, EPA, ASTM) (Continuous I&M)

Elements To Be Measured	Accumulation in Animals, Soil, Litter, Vegetation (6)	Atmospheric	
		Gasses (7)	Particulates (8)
Pb	x		x
Cd	x		x
As	x		x
SO_2		x	
O_3		x	

LEVEL OF EFFORT III (Development of national trend sets)

Elements To Be Measured	Rainfall (1)	Surface Waters (2)	Atmospheric Deposition		Surface Waters (5)
			Wet (Rain) (3)	Dry (Dust) (4)	
Trace metals			x	x	x
TSP					
$HNO_3NH_3NO_x$			x	x	
Halogenated Hydrocarbons			x		x

LEVEL OF EFFORT III

Elements To Be Measured	Accumulation in Animals, Soil, Litter, Vegetation (6)	Atmospheric	
		Gasses (7)	Particulates (8)
Trace metals	x		x
TSP			x
$HNO_3NH_3NO_x$			
Halogenated Hydrocarbons	x	x	

GEOPHYSICAL INVENTORYING AND MONITORING

LEVEL OF EFFORT I

Objectives:

...To develop basic information necessary to characterize Park Service sites.

...To establish reference materials important to research and monitoring projects in other categories.

Recommendations:

Event records should be kept to provide accounts of those unique or significant occurrences which can be characterized as having observable physiographic responses. Event recordings are to include the time, place, size, intensity, etc. of any defined parameter impinging on a system in a recognizable way, such as seasonal events (e.g., snow-pack, dust storms, floods, windthrow), but also unique, unusual, or catastrophic geological or meteorological events (e.g., fire, floods, earthquakes, volcanic eruptions, erosion).

Records of daily maximum and minimum air temperatures, precipitation events, atmospheric conditions, and maps developed to delimit the nature of the Park Service site and resource are essential.

Geological 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 that standardized scales

should be used at Level II. Aerial photos and LANDSAT data should be utilized at some regular interval as these provide national statistics, published materials, and/or new data for identifying and measuring specific features. The location, size, and number of streams, lakes, wetlands, and groundwater supplies should be mapped from available information and field checked. Major drainages should be given particular attention for future use as possible major representative study sites in biological monitoring.

Completed maps, combined with climatic data, will support vegetation mapping activities, will provide initial data for habitat classification determinations, and can be used to support the establishment of sample sites, permanent plots, and aquatic studies.

Products:

1. Records of daily geophysical conditions, such as climatic data.
2. Event records.
3. Maps of several types, completed with appropriate geological and other data.

LEVEL OF EFFORT II

Objective:

...To gather additional data required to more completely assess the dominant processes which characterize a site or area.

Recommendations:

The additional data gathered are to be worked into tabular form and then used to deduce gross trends and to form the basis for more detailed characterization of the site for comparative analyses with other sites. The comparisons then can be measured for anthropogenic change for special correlative studies.

Level II activities require additional standardized mapping (i.e., scales of

1:24,000; 1:60,000; or 1:1,000,000), 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 given high priority.

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

The data collected and worked into tabular form for Level of Effort II further characterize those physical, meteorological, hydrological, and geological variables which can assist with the assessment or analyses of species' communities and habitat responses to the atmosphere and lithosphere. These data permit the qualification of results from chemical monitoring, and from the results, hypotheses that can be formed to carry out certain Level of Effort III studies.

Products:

...Tabular work-up of data collections.

LEVEL OF EFFORT III

Objectives:

...To establish a detailed data base which separates random event physical changes from physical occurrences of local, regional, or global changes that are predictable from published and earlier known analyses.

...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 and detailed measurements of meteorological and hydrological parameters on a regular basis. These can be used to support quantitative impact analyses related to community dynamics and processes of change. (For instance, a WHO weather station can establish links between Biosphere Reserves and a global network of stations gathering similar data to monitor meteorological trends.)

For remote sites, transmission of data to satellites and back to central points is achievable without great difficulty, and should be considered when appropriate in order to reduce personnel costs.

Parameters of issues of clear global interest (e.g., CO2, 03, ionizing radiation) are to be monitored to determine the degree and extent of their roles in the natural environment. Regional and local issues (e.g., groundwater depletion, loss of forestland, desertification) are equally important, and should be identified at the earliest feasible time.

Products:

1. Detailed geochemical and hydrological monitoring through automated stations operating on a continous basis.
2. Specialized maps.
3. Detailed and closely spaced (time-wise) data sets.

..YSICAL INVENTORYING AND MONITORING

Function	Level of Effort* I	II	III	Reference
A. BASIC INVENTORYING FOR ALL AREAS				
1. Develop event records				
a. For events that are unique, unusual, or catastrophic.....	x	x	x	
b. For events that reasonably can be expected from historic records.....	x			
2. Develop maps				
a. Using imagery from satellites.....	x			
b. Using aerial photography:				
(1) of the 1:100,000 or 1:250,000 scale.....	x			
(2) of the 1:24,000 or 1:60,000 scale.....		x		
B. GEOLOGY				
1. Develop maps at reconnaissance level				
a. Geologic maps				
(1) Using 1:100,000 or 1:250,000 scale.....	x			
(2) Using 1:24,000 or 1:60,000 scale.....		x		
2. Develop special purpose maps showing:				
a. Geologic hazards (e.g., flood plain maps).....			x	
b. Channels and channel characteristics			x	
3. Indicate physical geology and mineralogy				
a. Soil analyses.....		x		
(1) Organic content.....		x		
(2) Water holding characteristics...		x		
(3) Mechanical analysis.....		x		
(4) Physical analysis.....		x		

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* Levels of effort range from I, the most basic level of inventorying/ monitoring activity, through III, the most complex level.

Function	I	II	III	Reference
(5) Water erodibility (index).....		x		
(6) Infiltration rate.....		x		
(7) Soil productivity (composite index).....		x		
(8) Cation exchange.....		x		
b. Sediment transport		x		
(1) Dissolved.....		x		
(2) Suspended.....		x		
(3) Bed load.....			x	
c. Mineralogy.....		x		
C. HYDROLOGY				
1. Develop watershed maps				
a. Of the 1:100,000 or 1:250,000 scale..	x			
b. Of the 1:24,000 or 1:60,000 scale....		x		
2. Develop special purpose maps				
a. Groundwater (water table).....		x		
b. Other.....		x		
3. Inventory through description				
a. Streams.....	x			
b. Lakes.....	x			
c. Wetlands.....	x			
d. Groundwater.....	x			
4. Indicate physical parameters				
a. Temperature (maximum/minimum)				
(1) Stream (monthly).....		x		
(2) Lakes (seasonally).....		x		
(3) Wetlands (seasonally).....		x		
(4) Groundwater (seasonally).....		x		
b. Turbidity (sechi disk)				
(1) Streams (episodically).....		x		
(2) Lakes.....		x		
(3) Wetlands.....		x		
c. Discharge (recording gauges)				
(1) Streams.....		x		
(2) Lakes (in and out flow).....		x		
(3) Wetlands.....		x		

Function	Level of Effort I	II	III	Reference
d. Stage (recording)				
(1) Streams	x			
(2) Lakes	x			
(3) Tides	x			
e. Automatic gauging				
(1) Temperature, discharge stage			x	
D. METEOROLOGY				
1. Indicate meteorological parameters				
a. Precipitation				
(1) Monthly totals	x			
(2) Daily and weekly totals		x		
(3) As recorded by gauges along precipitation gradient			x	
b. Air Temperature				
(1) Daily	x			
c. Atmospheric properties as indicated at closest available station and stations				
(1) Wind speed and direction	x			
(2) Humidity	x			
(3) Other aspects	x			
d. Atmospheric properties as indicated at standard station on-site (to include short wave isolation, recording hygrothermograph)		x		
e. C02, 03 monitor			x	
f. Ionizing radiation background levels			x	
g. WMO recording station			x	

BIOLOGICAL INVENTORYING AND MONITORING

LEVEL OF EFFORT I

Objectives:

...To monitor biological characteristics of ecosystems with minimal use of equipment, minimal cost, and limited availability of trained personnel.

...To provide survey information which facilitates subsequent expansion of monitoring efforts to assess areas requiring efforts at 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 objective is to obtain the best possible map upon which the boundaries of the area can be marked. This should be reproduced on a scale which permits mapping of major landforms, rivers, streams, lakes, forests, grasslands, etc. It should include any obvious natural 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.

As 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 time.

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 area. Special notice should be made of species which are of potential economic, managerial, or international significance. Such lists may already exist, but they also may be derived from regional floras or 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 or aesthetic appeal, or those that present special management problems, are also desirable. This basic knowledge will help identify key species for which population analyses (Level II) will be required.

Products:

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 OF EFFORT II

Objectives:

...To collect quantitative data necessary to develop long-term management plans.

...To study population dynamics.

...To begin to integrate data contributing to the understanding of community structures and dynamics.

Recommendations:

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, its analysis, and modeling is required at this level, and should be developed with two major points in mind: (1) that the system should be designed with long-term objectives, and be modifiable without loss of previous investments; and (2) that coordination between areas, 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 areas.

A map should be made that details landforms, natural barriers, and vegetation communities. Maps should be kept for each of the species chosen to be monitored, and should be outlined to show species distributions and abundances. These will provide accessible pictorial references of changes taking place in species distribution and abundance. They will also provide

local coordinates for quantification of distribution. Relationships should be explored between observed population distributions, dispersion, and abundance, and the geophysical, chemical, and demographic features of the area. In addition to providing first qualitative summaries of processes in the communities, these maps will enable scientists to select directions and priorities for emphasis in subsequent research and monitoring. The establishment of regular monitoring sites and transects will provide means of extracting additional data quantitatively from geographical localities. Aerial photography will support both the mapping and 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 to be environmental indicators, as well as species of particular importance to humans. It may be feasible in some habitats, such as arid lands, to monitor most, if not all, species contained in the area. However, a similar objective in most other tropical or temperate habitats is unrealistic.

Concurrent to these efforts, other measurements which contribute to the analysis and understanding of long-term population dynamics of the key species should be made. 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 areas.

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.

Products:

1. A complete species checklist;
2. A detailed map of communities, including aerial photographs;
3. A distribution map that reflects abundance and dispersion, including movements, of each of the key species;
4. Transects and specific monitoring sites established and data recorded regularly;
5. Measurements made of population dynamics in key species, and population models developed;
6. Data critical for Level III to measure dynamics of communities and long-term effects of impact.

LEVEL OF EFFORT III

Objectives:

...To integrate population models into community models;

...To integrate biological data with those of geophysical, chemical, and demographic monitoring efforts.

This action will lead to the development and continuing enhancement (by ongoing monitoring) of management systems and impact evaluations for the areas.

Recommendations:

This effort level requires personnel acqainted 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 carried out 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.

Products:

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 the areas which have a sound base and which are easily modified;
5. A data storage-retrieval-analysis system which is consistent in format and permits coordinated studies with other biological areas.

BIOLOGICAL INVENTORYING AND MONITORING

Function	Level of Effort* I	II	III	Reference
A. EVENT RECORD**	x	x	x	
B. MAPS OF BIOLOGICAL INVENTORY				
1. Develop vegetation maps		x		
2. Develop species distribution map of plants of special interest (populations/ species)			x	
C. SPECIES INVENTORIES				
1. Develop checklist of vascular plants	x			
2. Develop checklist of mammals, birds, and fish	x			
3. Develop checklist of other species of special interest		x	x	
4. Indicate species that are rare, endangered, or exotic	x			
D. POPULATIONS AND POPULATION DYNAMICS				
1. Indicate measurements (standard procedures)		x	x	
a. Dispersal				
b. Dispersion (including movements)				
c. Population size				
d. Population density				
e. Age structure				
f. Growth/recruitment/productivity				
g. Regulation				

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* Levels of effort range from I, the most basic level of inventorying/ monitoring activity, through III, the most complex level.

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

Function	Level of Effort I	II	III	Reference
h. Fluctuations				
2. Integrate population dynamics		x	x	
E. PHOTOGRAPHY				
1. Develop general habitat records (min.: 1:60,000; color: IR)	x			
2. Develop aerial records		x		
3. Develop transects (permanent photo points and markers)		x		
F. COMMUNITY DYNAMICS				
1. Give qualitative descriptions		x		
2. Give quantitative descriptions				
a. Integrating population dynamics ..			x	
b. Showing trophic relations			x	
c. Indicating changes in species composition			x	
d. Integrating events into community dynamics			x	
G. MODELS				
1. Create population models		x		
2. Integrate population models into community models			x	
3. Refine community models and create alternative models			x	

ANTHROPOLOGICAL INVENTORYING AND MONITORING

LEVEL OF EFFORT I

Objectives:

...To document direct, human related effects from inside and outside the park's areas on natural ecosystems within Park Services areas.
...To identify methods that can be used to minimize negative impacts.
...To collect data for the development of a management plan.

Recommendations:

Specialized land use maps should be developed to delimit the boundaries of human use activities, such as slash-and-burn, gathering of firewood, and settlements, as these can provide very useful information in determining the location of human pressures. They also can be used to qualify data gathered in other categories. All public facilities serving human populations should be included on the land use maps, as should research and training activities, including the facilities these use. In addition, literature published and instruments available at the latter should be documented.

Range of the area's use for forage by economic species, such as cattle, also should be recorded on maps, and the species should be identified by type and number.

At the same time, ownership and economic bases of all the site's resources--factors that are related to the types of impacts that might be expected in the future--should be documented in as precise terms as possible, using readily available data.

Records, including descriptions, should be kept of specific aspects of human organization and activity. These need to be accounted for in other monitoring categories, as their existence will permit the separation of localized, regional, and/or global phenonmena.

Products:

1. A list of all resources available.
2. Documentation of ownership and economic bases of all resources from readily available souroes.
3. Land use maps developed to indicate all human activities, and range of use by human's possessions, such as cattle or pets or recreation vehicles (e,g., snowmobiles).
4. A list of the literature published and instruments available at any training facility.
5. A list of the species on the site, with an indication of type and number.
6. Records describing specific aspects of human organization and activities.

LEVEL OF EFFORT II

Objectives;

...To begin quantifying uses of NPS areas. including aspects of human activities and organization that can be expected to have a dominant effect on the site.

...To evaluate goals and priorities that will become the basis for the management plan.

Recommendations,

The history of the sites' land uses and the present nature of the sites' uses by humans should be learned and understood in context of the area's history and values.

Each area should collect data for the development of carrying capacitY determinations.

Products:

1. Data that lead to the understanding of relationships between human use/consumption and biological productivity.
2. The quantification of economic productivity, and the yield or sustainability of natural ecosystems.

ANTHROPOLOGICAL INVENTORYING AND MONITORING

Function	Level of Effort I	Level of Effort II
A. EVENT RECORD		
1. Record unique or unusual anthropological events, such as migrations. effects of droughts, disease epidemics, shifts in fertility	x	x
2. Quantify, where possible, each of the events cited	x	x
B. MAPS		
1. Develop maps to indicate present areas of use	x	
2. Develop maps to indicate past areas of use and the kinds of uses		x
C. HUMAN ACTIVITIES		
1. Identify each type of activity present (e.g., farming, grazing, subsistence, forestry, mining, wilderness, hunting, fish, recreation)	x	
2. Quantify the identified activites (e.g.. yield/acre, board feet, number of visitors)		x
D. OWNERSHIP		
1. Indicate whether ownership is public or private for each area	x	
2. Indicate owner for each area and size class.	x	x
3. Indicate total number of owners		x
E. DEMOGRAPHY		
1. Human population (number of residents, visitors, and neighbors of park area)	x	
2. Age/sex distribution		x
3. Educational levels	x	
4. Housing (types and locations)		x
5. Per capita income and sources		x
6. Nationality of visitors		x

Function	Level of Effort I	II
F. ANIMALS		
1. Indicate number of individuals of livestock.	x	
2. Indicate number of livestock species, groups, herds	x	
3. Identify commercial species used		x
4. Indicate numbers and kinds of pets and other domestic animals		x
G. LEGAL MATTERS		
1. Cite acts, regulations, policies, etc. that affect the Park area	x	
2. Indicate management activities and priorities (type, frequency, extent)	x	
3. Cite Management Plan	x	
H. EDUCATION ACTIVITIES		
1. Indicate any research/education/training activities in area	x	
a. Document the type of such activity,	x	
b. Indicate the number of staff, kind of staff, budget, and facilities for the activities		x
I. REGIONAL LAND USE PLANNING		
1. Indicate regional public facilities (hospitals, labs, etc.)	x	
2. List services available (e.g., water, health, electricity)	x	
3. Quantify all of the public facilities and services available		x
J. OTHER SOCIAL SCIENCES STUDIES		
1. List any human studies taking place	x	
2. List any econometric studies taking place	x	

QUALITY ASSURANCE AND QUALITY CONTROL IN GATHERING DATA

The goals of inventorying and monitoring (I&M) are to detect changes in natural systems and to quantify them statistically, if they are caused by anthropic factors. A commitment by scientists and other technical personnel to the collection of quality I&M data over the long-term is necessary if the evidence for the effect(s) of anthropic factors are to be shown to be significantly altering natural rates of change. Only consistency in the collection and analysis of long-term data results in data accuracy and the ability to detect trends. (Many data sets have been lost because of inconsistency, and long-term data sets are especially vulnerable.)

The principal objective of any quality assurance/quality control (QA/QC) program is the production of data which are of a quality consistent with known levels of accuracy (the sum of random and systematic error), and precision (mutual agreement among replications). Quality assurance, or the application of procedures which reduce sampling and analyzing errors for improved data precision, begins with initial data collection, and is in place throughout data analysis, integration, and storage.

Common quality assurance procedures, routinely applied, include

...use of consistent collection and analytical methods over time,

...use of equivalent monitoring equipment among different sites,

...use of consistent formats in field and laboratory data reporting and transfer of files,

...use of procedures that maximize the capacity to integrate data sets with a minimum of manual data re-entry,

...maximum use of automated data handling techniques that ensure quick access to recently acquired data and ease of access to all data, and

...use of existing and proven data collection protocols.

Quality control, or the application of specific procedures in sampling and analysis to ensure accuracy of results, is to be built into any inventorying and monitoring effort. It begins with data collecting.

The justification for change in any specific steps employed in gathering data is substantiated principally by changes in data accuracy objectives. For example, the statistical analysis of data that document circumstances that could result in loss of data collection consistency, may dictate a change of procedures to improve accuracy. In addition, revised procedures may be required because existing data accuracy is found to be insufficient to detect trends. However, in no instance are new methods to be employed merely for convenience or on the suspicion that they may improve data accuracy. Rather, new methods are to be considered when it has been determined that there is a need for data with better accuracy. At that point, change can be brought about by calibration of the "old" and "new" procedures, generally for one year's time.

A major factor in quality assurance is consistency in the use of procedures, a process best ensured by employment of qualified and committed personnel. When the I&M effort includes large amounts of both spatial and temporal data collected over a network of sites, as is the case with the Park Service, the quality of personnel can be a major factor in the level of quality assurance. There is no substitute for attention to detail: This comes only from personnel who are committed to the long-term objectives of I&M. Through familiarity with the natural variables they are observing and/or an understanding of analytical procedures, these are the people best able to detect situations that appear to deviate from the norm. And it often is

these persons' observations or suspicions that are the keys in detecting the need for better procedures, or perhaps even a new conceptual approach in data acquisition or research.

By necessity, I&M in the Park Service must be long-term. Personnel involved must be committed to the long-term objectives and the processes required to achieve them. There are few if any short-term products. The reward is the professional satisfaction that comes from doing quality work in a consistent manner.

INVENTORYING AND MONITORING
INFORMATION MANAGEMENT

Two important topics are central to the proposals that follow: Data management and data quality. (See Chapter 6.) Large quantities of existing data will be assembled and new data will be produced by this Inventorying and Monitoring (I&M) Program--a program that must result in a usable, resource inventory.

A usable resource inventory is a quality assured, computerized data base with a variety of integrated data themes to which analytical methods can be applied (e.g., correlation, coincidence, modeling, etc.). Through computerization, the myriad pieces of park resource information can be integrated, resulting in the critical link among categories of data that becomes the communication network among the various park resource management programs and activities.

For instance, an integrated, computerized data base could provide a plant ecologist studying species decline with data such as soil type; acid deposition; air quality; rainfall; elevation, slope, and aspect; proximity and coincidence with visitor activities; vegetation types; wildlife habitats; or hydrological features. Without computerization, these data would reside in file drawers or reports in separate offices and come together--if the usual occurred--only through happenstance.

As data quality must be documented for long-term utility, detailed quality assurance/quality control plans must be implemented and quality estimates must be established for existing data sets. To augment this process, early determination of what data to store in map files and/or attribute/data files will be needed.

Establishing an effective data management program for I&M will complement other NPS efforts to make effective use of its data resources, specifically, the Data Standardization Process and COMMON.

In 1985, the Service's ADP Standards Committee established a Data Standardization Process which has been incorporated into the NPS ADP Standards Manual. Among other things, the standards established a data dictionary--a data base that keeps track of how data elements are defined and used in the Service. The goals of this data management/dictionary process are consistent with those described above: to simplify the communicating, sharing, and compiling of data among different NPS areas, offices, and program areas; to facilitiate the design of new data bases by maintaining a sourcebook (data dictionary) of new data elements that have already been defined and field tested; and to provide a reference as to where particular types of data exist in the organization. Various program areas (i.e., Cultural Resources, Housing, Maintenance Management) are currently participating in the Data Standardization Process. The Geographic Information Systems Division (GISD) has directed the revision of Servicewide GIS ADP Standards to include standards for GIS data base construction. It is important to note that compliance with the data base construction standard is required and that this standard will assure data file exchange as the minimal level of that standard. Specifically, data bases that are constructed for a user--either park, region, or servicewide program--can be used by any other user's hardware/ software configuration. In addition, GISD has initiated action to publish standards for linking text data bases (attribute information) to spatial data bases and for preparing mapped information digitizing.

By participating in the existing Servicewide data management framework, the I&M program will benefit from the experience, and expertise will be derived from existing NPS data management efforts while contributing to the larger coordination of Servicewide data.