STANDARDS AND GUIDELINES FOR NATURAL RESOURCES INVENTORYING AND MONITORING

NPS-75

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FOREWORD

This first attempt to develop Servicewide "Standards and Guidelines for Natural Resources Inventorying and Monitoring" represents a draft working document that is part of a five-step process, progressing in series and in parallel, leading toward full implementation of a Servicewide natural resources inventorying and monitoring (I&M) program in NPS field areas.

This draft document, concurrently with the review of park I&M activities and implementation of the pilot park I&M program, will test the reasonableness of the proposed approach and guide the implementation of the Servicewide I&M program. As the program progresses, the individual elements will be reviewed and revised; technical protocols, quality assurance plans and data management plans will be developed; and, individual park I&M plans and programs will be initiated.

The following list represents the ongoing activities that support this document and the implementation of the Servicewide Inventorying and Monitoring (I&M) program:

1. Systematic assessment of existing NPS I&M activities:

    a. As a first step, polling the parks to ascertain the present status of I&M efforts.
    b. Convening technical working groups to review in detail I&M activities at select parks.

2. Promulgation of recommended I&M guidelines and standards:

    a. Provision of technical guidance in the development and promulgation of individual I&M guidelines and standards. This broad and substantial charge includes determining the future degree of specificity for guidelines and a description of the minimum level to be accomplished.

b. Counsel to the Directorate on the steps toward Servicewide implementation of I&M.

c. Review of progress and quality control in the pilot parks and Servicewide I&M program.

d. Guidance in the development of technical workshops to be conducted in pilot parks, and at Mather and/or Albright Training Centers, for responsible staff Servicewide.

e. Development and recommendation of protocols for data management.

f. Drawing on professionals from within and outside the Service to accomplish a.-e. above.

3. From the list of parks nominated by the Regional Directors the selection of pilot I&M areas with strong I&M programs on which to build, or having critical needs for major I&M efforts.

4. Recommendation of stages of implementation of I&M in the parks:

   a. The convening of working groups, following the guidelines established, to assess the elements of Chapters 3, 4, 5, & 6; assessing which elements are appropriate at each level and determining the appropriate method/methods for I&M data collection.

   b. Convening of the working group annually to reassess the park programs.

5. Development of a management plan for I&M, including budget and staffing initiatives; final organizational responsibilities, roles and functions, etc.; procedures of evaluating and tracking program success; and, development of budget tracking procedures and staffing plans.

INTRODUCTION

Policy

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 comparison with other, more altered parts of the home of humankind may be made.

Definitions

Natural resource inventorying is the process of acquiring information on park resources, including the presence, distribution, and condition of plants, animals, soils, water, air, geological and natural features, biotic communities, and natural and human-induced processes.

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

Statement of Need

The National Park Service is responsible for the management of natural resources in a manner that conserves them unimpaired for future generations. It is essential, therefore, that park managers know the nature and condition of the resources under their care, have the means to detect and document changes in those resources, and understand the forces driving those changes. With parks increasingly surrounded by altered environments and experiencing externally caused impacts on park resources, and with growing awareness of the effects of human activities within the parks, natural resource baseline inventories and subsequent monitoring are an essential basis for park management. Simply put: To determine appropriate management actions, we must know what resources we hold in trust, how they change over time, and how those changes are related to human activities. Inventorying and monitoring are essential to determine our fidelity to or deviation from desired resource conditions, to assess the impacts of human influence, to direct management intervention, and to measure the subsequent success or failure of that intervention.

Inventorying and monitoring are fundamental elements of a National Park Service program that includes (1) scientific investigation to understand the ecological, ecosystem, and anthropogenic processes that underlie park resources; and (2) the management of those resources and regulation of visitor activities based on the information acquired. It should be noted that this program will support and augment future resources analyses but will not replace ongoing research and resources management activities. These interdependent activities are all necessary for the protection of park resources.

In a very real sense, inventorying and monitoring may be the most important legacy the Park Service can provide American conservation. Probably no ecosystem on earth remains totally unaffected by modern human activities. However, in a world in which wild places have become few and precious, knowledge of the composition and function of relatively unaltered wild systems has become invaluable. The information collected in this program must underlie any fundamental knowledge of those systems.

BACKGROUND

It is the policy of NPS "to provide accurate scientific data upon which all aspects of planning, development and management of the units of the System may be based" (Management Policies of the NPS IV-2, 1978). The extent to which natural resource inventorying and long-term monitoring have been accomplished varies greatly throughout the Service. Few parks, other than some International Biosphere Reserves and National Acid Precipitation and Assessment (NAPA) sites, have many of the elements of a comprehensive I&M program. Most parks, however, have some of those elements.

The Forest and Rangeland Renewable Resources Planning Acts (RPA) of 1974 and 1976 express Congressional insistence upon inventorying and monitoring of natural resouces on all public lands in the United States.

The National Environmental Policy Act (NEPA) contains explicit requirements of sufficient knowledge of resources (i.e., baseline inventory) to determine effects of management actions.

NPS was criticized by the General Accounting Office in its February, 1987 report to Congress entitled "Parks and Recreation: Limited Progress Made in Documenting and Mitigating Threats to the Parks" for lack of followup of the 1980 State of the Parks report. The principal reasons for this failure were lack of fundamental resource data (inventory) and any measures of change (data from monitoring).

Inventorying and monitoring require effective policy guidance, oversight and support, and a comprehensive Servicewide system to assure their successful accomplishment in all park units. Such a system should include a Servicewide recognition of inventorying and monitoring activities as fundamental, high priority management responsibilities at each level of the agency. Successful execution of that responsibility depends upon it being fully accepted and integrated into management decisions at all levels of the National Park Service.

Long-term monitoring needs must, at the earliest possible time, be base-funded and closely tracked at all organizational levels to assure the continuity upon which they depend. The program cannot succeed over the long term--forever, in the context of the Park Service mandate--unless it is fully institutionalized at the level of park operations. It is unlikely this program can succeed without commitment of new funding--not redirection from other essential resource programs--and additional staff. Falling neatly between traditional Park Service research and resource management responsibilities, I&M will require the explicit cooperation of both of those functional areas at the field level, and the formal support of administration at every level.

Implementation of a Biological Diversity Program will require that inventorying and monitoring be in place, as these will be the critical sources of data for setting parameters of any biological diversity programs and for evaluating their ultimate success. In turn, models of biological diversity may guide selection of appropriate natural resource elements and processes to monitor.

The Natural Resources Assessment Action Program (NRAAP) depends ultimately for its soundness and effectiveness on a foundation of systematic Servicewide inventorying and monitoring, which must be in the highest priority ranks of NRAAP, at its outset and thereafter (see also Natural Resource I&M Initiative, 1987).

No universally appropriate "off the shelf" procedures are available for direct implementation of I&M, nor is it likely that one set of procedures will be appropriate, in kind, in depth, or in technical approach, to all park units. Although the advice, counsel, and cooperation of other natural resources agencies, universities, conservation organizations, and scholarly associations is highly desirable, the Park Service must carry a large measure of responsibility for directing this new field of endeavor.

Discussion

The units of the NPS, as previously noted, are diverse and often unique and will have many individual resources information requirements. This initiative is not meant to answer each individual resource question but to provide a level of knowledge Servicewide that will allow for more directed study, problem analysis, and problem solution--in other words a "minimal" working program. All parks have common information needs. Adequate I&M guidelines must (1) provide standards for meeting these needs, and (2) provide minimal standards for subsequent, more intensive data collection.

The following discussion pulls together a number of existing concepts, ongoing monitoring and inventorying programs (both within and outside NPS), and looks at past experience as a first effort to develop a systematic Servicewide data collection plan.

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 invariably site specific. Thus, not all areas will be geo-observatories, but all areas will fit into a data collection scheme that will provide to park management that information needed to understand, interpret, and conserve park "natural" resources within the regional and global framework.

Such an holistic approach requires that we observe and document the "elements of change" for park systems/ecosystems to the degree necessary to interpret and analyze the cause of change. To accomplish this we must inventory biotic and abiotic elements and document important ecosystem processes and perturbations (i.e., human use, erosion, flood, fire, wind, earthquakes, volcanoes, migrations, biogeochemical cycle changes, etc.). Therefore, step one, the inventorying of the I&M process, is to document the status of each park's knowledge relative to its geographical placement. A high I&M priority would be to complete needed park inventories where significant information gaps exist. The inventory establishes our point of departure for required monitoring activities.

The monitoring program for each area will be guided by a close analysis of existing "completed" inventory data sets. Lack of inventory data invariably causes some uncertainty about the scale of site specific activities and causes park resources and resources management difficulties. We anticipate that Servicewide coordination of I&M program development will lessen these difficulties and will assist the regions and field areas in developing the resources required to complete initial I&M activities.

There exists today a number of common, persistent, and troubling issues that enable us to identify a hierarchical plan or process for obtaining data elements. The importance of each element within this plan must be referenced to management needs as more specific activities continue to be identified. As we have begun to review the parks with ongoing I&M activities, we have quickly determined a number of common elements and goals.

Clearly the park responses are very disparate as they are driven by a number of overlapping management concerns. They can, however, be approached as representative of programs being driven by a number of related global, regional, and local issues (viz., visibility, atmospheric deposition, population changes, distributions and relationships, land use change, and resource integrity), which have resulted in a set of similar, site specific measurements. Planned multiple park natural resources monitoring programs identified as presently having a set of uniform data collection requirements from which we can draw experience are limited but examples do exist and include:

(1) National Atmospheric Deposition Program (NADP)
(2) National Acid Precipitation Assessment Program (NAPAP)
(3) Visibility (areas)
(4) AFFIRMS
(5) Integrated pest management

Nevertheless, an ongoing review of park data collection and analysis activities will improve on this first attempt at suggested guidelines.

Combining the numerous threats identified in the State of Parks Report 1980 and its 1987 successor, NRAP, with our cursory review of a few park programs, we find that the following priority resource management issues can be used to provide important direction to the structure of the I&M program:

1. Life zone or biogeographic changes (viz., grizzly bear in Greater Yellowstone Ecosystem, numerous local individual species problems and regional species population changes);
2. Human encroachment (viz., recreation, industrial development, resource exploitation);
3. Biogeochemical changes (viz., acidification, air and water pollution, forest decline);
4. Global climate change
   a. Temperature change (viz., life zone changes, melting snow fields and glaciers);
   b. Mean sea level change (viz., shoreline erosion);
   c. Precipitation change--patterns and amounts (viz., flooding, drought)

To digress a little and borrow from the words of Peter Denning, "The production of scientific information is exceeding anyone's ability to assimilate and use it" (American Scientist V.75, 1987). We, therefore, must make the effort to integrate computing and analytic technologies into the processes of investigation and data collection. We must not forget, however, that people play the central roles in the knowledge network. It is required that individuals communicate in pursuit of knowledge. Having said this, our concern now is with the proper recording of knowledge about park resources.

Two important topics are central to the chapters that follow. They are data management and data quality and will be discussed further in Chapters 7 & 8. Large quantities of data are being and will be produced by this program; uniform scaling and documentation will be required. NPS has committed to a GIS program and the I&M data management must be compatible and complementary. To augment this process, an early determination of which data to store in map and tabular form will be needed.

Data quality must also be documented for long-term utility. Thus, detailed quality assurance/quality control plans must be implemented and quality (accuracy/precision) estimates must be established for existing data sets. This will be a long, laborious process but it must be done.

Development of site specific I&M guidelines and standards requires a disaggregation of biotic and abiotic elements both spatially and temporarily, as ecosystem processes of importance to park management occur at differing rates and in differing geographic patterns. Also, some processes are thought to be geographically consistent at global or regional levels, while others are local and site specific. To account for these differences we expand on the preliminary list of elements previously presented (NPS, 1987) and employ an aggregated list of data sets to be filled relative to known processes or agents of change. The result is a set of required measurements that can be implemented by Park unit personnel according to designation, location, and size.

Expanding on work accomplished in 1979 by MAB, a structure for aggregation of data sets to respond to these resource requirements is proposed. The kinds of data sets would include:

1. Chemical (Chapter 3)
2. Geo-physical (Chapter 4)
    - Hydrologic
    - Soil
    - Meteorological
3. Biological--terrestrial and aquatic (Chapter 5)
4. Human Use (Chapter 6)

It should be noted here that agreed-upon standards for collection of these data elements do exist in many cases. What is lacking is agreement on what data must be collected -- when and where? Sources for established standards and criteria to be searched are:

Chemical - ASTM, NADP, EPA, etc.;
Geological - USGS, NASA;
Meteorological - WMO;
Soils - USSCS, USGS;
Hydrology - USGS, EPA;
Human Use - NPS (Maintenance Division, Lands Division, Statistical Unit, Cultural Resources Divisions), Federal Highways, etc.;
Biological - NPS, NSF, USFS, EPA (the least uniform will require some early agreement).
Many protocols may be appropriately referenced as in Herrmann (1987) and incorporated for testing.

Once agreed upon, I&M activities must adhere to the following requirements:

1) Parameters sampled and techniques used will be limited to those widely accepted for evaluating and/or predicting ecological change.
2) Techniques used will not be changed unless a new technique can be calibrated against the old.
3) Samples will be cataloged and stored using standard museum procedures.
4) Filed plots or sites must be secure and appropriately protected.
5) Data archiving must be secure.

Given the complexity of the aforementioned needs, the approach based on MAB (1979) that has been chosen divides data collection into three levels where only a few identified issues and areas require the most intensive Level III measurements, while many would require Level II, and all but a few of the smallest NPS areas would be expected to meet the minimal Level I requirements. The following Chapters 3,4,5, and 6 develop a clearer definition of the three levels and present those parameters which are proposed to be required at each of the three levels of park activity.

Chapter 4

Physical and Chemical Inventory and Monitoring

Inventorying and monitoring (I&M) of physical properties and chemical elements and compounds present in parks establishes baselines and scales for ecological comparison. These data collections activities will often support or be integrated with biological data collection discussed in Chapter 5. Examination of and identification of specific physical resources substances (nutrients and pollutants) are aspects of I&M closely tied to understanding the nature of anthropogenically caused change in natural ecosystems.

Chemical I&M focuses on select substances in the environment, with the goals being to measure nutrient input and cycles, to detect undesirable substances and their modes of transport into and through the system, and to identify effects on elements of ecosystems. The I&M of natural substances and pollutants comes through examination of the atmosphere, geology, water, soil and litter, vegetation, and animals.

Physical I&M focuses on those geological, hydrological and meteorological records and data necessary to understand the relationships between the atmosphere, the hydrosphere, the lithosphere and the biosphere. These data provide as complete as possible an information base on the relationship of the hydrologic cycle to park ecosystems. Further, the physical I&M will identify important geomorphic hydrologic and atmospheric processes responsible for the character of Park natural resources and will monitor those processes most vulnerable or likely to change measurably or to cause fundamental changes to occur among Park resources and Park ecosystems.

Given the scope of these subject areas, particular efforts must be made to have effective standardization and quality control so that valid comparisons of data can be made later. Sampling precision and scale, and sample storage, chemical analyses, and data interpretation should be standardized. In practice, this is difficult to achieve. These issues are discussed more fully in Chapter 7.

Level of Effort I

Objective

The objective of Level I is to gather synoptic data describing the topography, geology, soils, hydrology, climate, and chemistry of water and atmosphere. These data are to provide an inventory of the Park natural resources to be used for future reference and to determine if more detailed studies and/or monitoring at a higher level is required.

Recommendations

Topographic and geologic maps should be obtained for most parks. Aerial photos and remote sensing data should be acquired at some regular interval to document land use and possible topographic changes. Procedures should be developed to record geologic, hydrologic, and weather events of an unusual nature and, for most parks, to obtain systematic records of weather. The location, size, and flow of streams, lakes, springs, wetlands, and groundwater supplies should be obtained from maps and field surveys. A survey of the chemistry of streams, lakes, springs, and groundwater for a basic list of chemical constituents should be done.

Products

The data obtained should be archived in park records and, if possible, a report should be written summarizing findings. The information should be reviewed by NPS technical and resources management staff to determine if further studies are required and if a monitoring program should be initiated for some natural resource areas.

Level of Effort II

The objective of level II is to develop a routine monitoring program for physical measurements or chemical constituents in order to assess processes that affect natural resources and to detect trends in measured quantities.

Recommendations

The most frequently occurring monitoring program involves water resource studies of the chemistry, flow, and properties of streams, springs, and lakes. The Service has a limited but on-going program of monitoring for the effects of acid rain, and the most likely water resources monitoring to be initiated would be for questions of water availability, quality, pollution, or flooding. Depending on the type of park hydrologic system, a monitoring program could involve periodic stream gauging, periodic sampling for dissolved constituents, water level measurements in wells, or measurements of physical, chemical and biological properties in lakes. Frequency of measurements depends on the system being studied. Other monitoring programs that would be necessary in some parks are for significant thermal features, volcanic hazards, or land slide hazards. A component of any monitoring program is a basic understanding of the system being monitored. For example, it is important to know the basic determinants of stream chemistry if one is to monitor it, but this may involve nothing more than a recognition that it is produced by rock weathering. Other systems may be much more difficult to understand in order to develop an effective monitoring program, for example a deep lake or complex watershed.

Products

Data should be tabulated, archived, assessed for consistency, and reviewed to detect trends or possible changes.

Level of Effort III

Objective

Monitoring or inventorying at level III involves the application of techniques normally used in a research context to understand complex systems or to monitor at extreme levels of sensitivity.

Recommendations

Work at this level should be undertaken when the problem to be studied requires more than standard techniques can accomplish. The broadest program in the Service at this level is monitoring for acid rain. Measurements of dissolved constituents in rain, constituents in dry deposition, and trace constituents in the atmosphere require a level of precision and technique not commonly applied. The study of some natural resources in parks will need this level of effort, because standard techniques are not adequate to provide required answers.

Products

Studies at this level will normally involve publication in scientific journals along with reports to Park Service management.

TABLE 1

SUGGESTED AREAS FOR CONSIDERATION
IN PHYSICAL CHEMICAL INVENTORYING AND MONITORING

Function	Level of Effort* I	II	III	References
A. BASIC INVENTORYING FOR ALL AREAS				
1. Develop event records				NPS
a. For events that are unique, unusual, or catastrophic	x	x		
b. For events that reasonably can be expected from historic records . .	x			
2. Develop maps				USGS,NASA
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		
c. Using special imagery, (SLR, magnetic, gravity, resistivity)			x	
d. Topographic Maps (1:24,000 x or best available scale)	x			
B. GEOLOGY				
1. Develop maps at reconnaissance level				USGS
a. Geologic maps (bed rock and surficial)				
1) Using 1:100,000 or best available scale)	x			
2) Using 1:24,000 or 1:60,000 scale		x		USGS
2. Develop special purpose maps showing:				USGS,USSCS
a. Geologic hazards (e.g., flood plain maps, special geological features)			x	NPS
b. Channels and channel characteristics			x	
c. Other special purpose maps (e.g. gravity anomaly, magnetic anomaly, resistivity, electrical conductivity, earthquake, heat flow, deforestation)			x	
d. Soils maps		x		USSCS

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

Function	I	II	III	References
3. Physical geology, mineralogy and soils				USGS
a. Soil analyses		x		
1) Organic content		x		
2) Water holding characteristics		x		
3) Mechanical analysis		x		
4) Physical analysis		x		
5) Radon flux		x		
6) Water erodibility (index) . .		x		
7) Infiltration rate		x		
8) Soil productivity (composite index)		x		
9) Cation exchange		x		
b. Sediment transport		x		
1) Suspended		x		
2) Bed load			x	
3) Eolian		x		
c. Principle mineral composition of geological units (same scale as bed rock geology)		x		
d. Geo-hazards		x		
C. HYDROLOGY				
1. Develop watershed maps				USGS,NPS
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				USGS, NOAA,NPS
a. Groundwater (water table)		x		
b. Bathymetry	x			
c. Other		x		
3. Inventory through description				USGS,NPS
a. Streams	x			
b. Lakes	x			
c. Wetlands	x			
d. Groundwater (hot springs, cold springs)	x			
4. Measure physical parameters				USGS, NOAA,NPS
a. Temperature (maximum/minimum)				
1) Stream (monthly)	x	x		
2) Lakes (seasonally)	x	x		

Function	I	II	III	References
3) Wetlands (seasonally)	x	x		
4) Groundwater (seasonally) . .	x	x		
b. Turbidity				
1) Streams (episodically	x	x		
2) Lakes	x	x		
3) Wetlands	x	x		
c. Stage and discharge (manual)				
1) Streams	x			
2) Lakes	x			
3) Tides	x			
d. Discharge (recording gauges)				
1) Streams		x		
2) Lakes (in and out flow) . . .		x		
3) Wetlands		x		
4) Cold springs		x		
e. Automatic gauging				
1) Temperature, discharge stage.			x	
D. METEOROLOGY				NAPAP,USGS, NPS,NOAA, USFS,WMO
1. Indicate meteorological parameters				
a. Precipitation				
1) Bulk measurements	x			
2) Daily and weekly gauged totals		x		
3) As recorded by gauges along precipitation gradient . . .			x	
b. Air Temperature				
1) Daily	x			
c. Atmospheric conditions as indicated at closest available station and stations				
1) Wind speed and direction . . .	x			
2) Relative Humidity	x			
3) Barometric pressure	x			
4) Other aspects (e.g. % cloud cover)	x			
d. Atmospheric conditions as indicated at standard station on-site (to include short wave insolation, recording hygrothermograph)		x		
e. CO_2, O_3 (other criteria pollutants)			x	EPA,ASTM
f. Ionizing radiation background levels			x	
g. WMO recording station			x	WMO

Function	I	II	III	References
E. CHEMISTRY (See Table 2)				
1. Selection of synoptic sites	x			ASTM, EPA,NPS
2. Determination of appropriate detection limits, methods of sampling and analysis, and parameters to be determined	x			
3. Select long-term sites representing unimpacted and, if appropriate, impacted watersheds		x		
4. Initiate long-term monitoring		x		
5. Develop hypotheses on causes of trends			x	
6. Design process-level studies necessary to test hypotheses			x	
F. MODELS (Conceptual - begin Inventorying and Monitoring program what, when and where to monitor)				
1. Create hydrologic models of surface, and groundwater for area	x			NPS,USGS
2. Develop meteorologic models for area				NPS,NOAA
a. Specific to wildfire suppression		x		
b. Integrate with hydrologic models		x		
3. Develop models of erosion, evolution of land forms, surface morphology, coastlines, etc.		x x		NPS,USGS, ARS,USSCS

Table 2

CHEMICAL MEASUREMENTS

at three Levels of Effort*

Elements to be Measured	Surface Waters (1)	Atmospheric Deposition: Wet (Rain) (2)	Atmospheric Deposition: Dry (Dust) (3)	Accumulation in Animals, Soil, Litter, Vegetation (4)	Atmospheric: Gases (5)	Atmospheric: Particulates (6)
Alkalinity	I	I				
pH	I	I				
Conductivity	I	I				
$SO_4^{=}$	I	I	II			
$PO_4^{=}$	I					
Total P	II					
Cl^-	I	I				
Total N	II					
NO_3^-	I	I				
NH_4^+	I	I				
K^+	I	I				
Na^+	I	I				
Ca^{++}	I	I				
Mg^{++}	I	I				
SO_2					II	
CO_2					II	
O_3					II	
SiO_2	I					
Coloform & fecal strep	I					
DO	I					
DOC	I					
CO_3	I					
HCO_3	I					
$HNO_3NH_3NO_x$	I		III		II	
Trace metals	II,III	III	III	II,III	II	II,III
TSP						III
Halogenated hydrocarbons	III	III		III	III	
Isotopes	III	III		III		

* For definitions of Levels of Effort I, II and III, see page 16.

BIOLOGICAL INVENTORY AND MONITORING

Execution of a biological inventory and establishment of a monitoring program within the NPS should take place in logical phases because they are ,in fact, part of a continual process leading to the acquisition of knowledge about the biotic resources of a park. These phases have been generally defined by the major tasks scheduled for completion at that level of effort. They are: Phase I: Identification and Location; Phase II: Analysis; and Phase III: Integration. The specific priority of a task/product within a phase depends upon the urgency of the information required, cost/benefit ratio, and natural planning sequence in which some information must be collected before the methodology for the next task can be determined. Moreover, information collection begun in one phase may well continue as tasks in later phases are initiated; it may--in the case of monitoring, for example--continue indefinitely. Thus, the sequence of information development that follows must be considered only a general guide. Further, additional tasks may be recommended by the park's scientific review team as issues arise. Because Phase I is designed to provide a park with a basic description of its biological resources, it is recommended that all units of the National Park System attain the level of information identified in Phase I. In some cases, however, particularly where native biotic resources are not a significant resource value, Phase I information may be sufficient.

This chapter describes tasks and products to be completed as well as a general order of priority for accomplishments but purposely excludes methods since standardized methods may vary with the resources being studied. A discussion of standardized methods will be the subject of a future addendum to NPS-75.

PHASE I: IDENTIFICATION AND LOCATION

Historical data base. A comprehensive picture of the present state of the park's knowledge of its biota and related factors, and the history of these resources, needs to be compiled from existing source materials, with as much information as possible (or at least references to it) transferred to computer data bases (text and map based). This information will typically be in the form of manuscripts, published material, maps, photographs, and--in some cases--existing geographic information system data bases. Of special importance are records of rare but significant events (i.e. floods, major landslides, eruptions). A bibliographic data base referencing the body of published and significant unpublished documentation on park biota and related resources is essential. Critical review of this historical data base is imperative to analyze the status and quality of existing natural resource information about the park and its environs.

Geography. A most important aspect of Phase I is the location of resources with respect to a modern, high resolution base map series (e.g. USGS 7.5' quads) and coordinate system (e.g. Universal Transverse Mercator). Whether or not a GIS data base has been developed at this time, resources are mapped to the accuracy and precision appropriate for eventual entry into a GIS data base. The map selected should be the largest scale i.e., have the highest spatial fidelity, appropriate to the subject. An accurate and comprehensive representation of the park landscape and its vicinity at a known point in time is compiled from aerial and ground photography, satellite data, and land survey. It is most important that the "study area" include surrounding areas that influence park biota. This "study area" is determined early in the inventory process because it is used to define the universe within which data are collected. A primary data theme to be mapped is vegetation communities and other land cover, usually derived from remote sensing prior to detailed fieldwork; such a map is invaluable in stratifying other kinds of sampling. Qualitative biotic community descriptions of the map classes are developed based on preliminary ground-truthing.

Species and populations. During Phase I, the presence of as many species as possible is established. It is an ultimate goal to establish an accurate inventory of all lifeforms within a park, but this is a long range goal. The historical data base can be a starting point, but an inventory must be based on empirical, not inferential data because Phase I data must be reliable and accurate enough so that it can be the basis for a effective monitoring program. Development of inventory priorities may be based upon criteria including taxonomic group; legal status (e.g. endangered); endemism; non-native species; species legal or illegally taken; species characterizing communities; heroic species; species described in enabling legislation. Ordinarily, all vascular plants and vertebrate animals are included in Phase I inventory, as well as other species of interest or importance (e.g. lichens in tundra communities; marine mollusks; gypsy moths and other non-native insect pests; major pathogens). Distributions of plant and animal species of special interest or concern are also to be developed in Phase I. The collection and curation of voucher specimens is encouraged to document inventory information.

PHASE II: ANALYSIS

Populations. Monitoring of population size (or density, cover) for selected species-populations of plants and animals is initiated based upon information collected in Phase I. This includes age, stage, or size-class structure as appropriate to understand population trends and condition. Similarly, population regulation factors are determined and monitored where appropriate: recruitment, growth, mortality, and productivity. Models of population dynamics and regulation are developed for certain species. Species-populations are selected based upon the criteria listed above (I. Species and Populations).

Communities. Community structure and species composition is developed (inventory) for all biotic communities in the park study area. This includes the proportional representation of different physiognomic types (e.g. herb, shrub, tree; invertebrate, vertebrate) and measures of abundance of the different species. These composition measures are geographically-based, but can also be used to specifically characterize biotic communities throughout the park study area. Such descriptions are quantitative and objective, permitting precisely repeated measures in future.

Geography. Important landscape patterns are mapped and studied. These vary from place to place, but may include migration corridors, habitat fragmentation, and a variety of abiotic features that help explain the distribution of biotic resources.

PHASE III. INTEGRATION

Populations. Genetic evaluations are conducted for species of concern, and determination made whether genetic status must be monitored. Generally these evaluations are only appropriate for small, isolated populations, those of a rare genotype, and those where genetic diversity may be a problem. Quantitative descriptions of population dynamics are extended to more species.

Communities. On the previously established system of field sample plots, abiotic components that help explain biotic conditions are recorded (inventory). These may include terrain, soil chemistry, soil moisture, water depth, temperature, etc. Changes in species composition are monitored quantitatively, as are other aspects of community dynamics (e.g. levels of pathology, species substitution). Population models are combined to develop community dynamics models.

Ecosystems. Important ecosystem-level factors include nutrient pools (e.g. nitrogen, phosphorus, carbon), decomposition rates, biomass of living and dead organic matter, energy flow, and productivity. These are ordinarily monitored only at selected sites, such as designated watershed and eco-centers of special interest. Quantitative descriptions of trophic relationships are developed. A model of energy and nutrient pools and fluxes is constructed for selected sites. Finally, an ecosystem model is developed to predict the impacts of various perturbations including management actions on the park's biotic resources.

Biological Inventorying and Monitoring

Phase I: Identification and location
Phase II: Analysis
Phase III: Integration

Task/Product	Phase I	II	III
A. HISTORICAL DATABASE			
1. Rare event records	x		
2. Bibliography of all resource descriptive documents	x		
3. Collection of manuscripts, old maps, photos, etc.	x		
4. GIS and related maps	x		
B. SPECIES			
1. Inventory of vascular plants including distribution	x		
2. Inventory of mammals, birds, fish, amphibians, and reptiles including distribution	x		
3. Inventory of other species of special interest	x		
4. Listing of species that are threatened, endangered, endemic or non-native	x		
5. Distribution maps of plant and animal species of special interest	x		
C. POPULATIONS			
1. For selected species:			
a. Distribution	x		
b. Population size (including density/cover if appropriate)		x	

Task/Product	I	II	III
c. Age/stage/size class structure		x	
d. Growth/recruitment/productivity/mortality		x	
e. Population genetics			x
D. COMMUNITIES			
1. Vegetation/land cover map (see F1)	x		
2. Community structure		x	
3. Species composition		x	
4. Important abiotic components associated with sample plots			x
E. ECOSYSTEMS			
1. Important nutrient pools			x
2. Decomposition			x
3. Biomass (living and dead)			x
4. Productivity			x
5. Energy flow			x
F. INTEGRATION			
1. Qualitative community descriptions to correspond with vegetation map	x		
2. Landscape patterns (e.g., fragmentation, corridors)		x	
3. Population models for species of special interest		x	
4. Quantitative descriptions			
a. Population dynamics			x

Task/Product	I	II	III
b. Trophic relationships			x
c. Changes in species composition			x
d. Community dynamics			x
5. Community models from population models			x
6. Nutrient cycling models			x
7. Ecosystem models			x

Task/Product	I	II	III
GEOGRAPHY			
1. Determination of study area and location of resources associated with an appropriate base map series and coordinate system	x		
2. Resources mapped accurately to GIS standards	x		
3. Accurate and comprehensive representation of park landscape (e.g., satellite, aerial photography, survey as appropriate)	x		
4. Digital GIS data base as appropriate (using consistent and stable base)		x	

HUMAN USE (ACTIVITIES) 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 Service areas.
...To identify methods that can be used to minimize human 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 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.

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 sources.
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 and present nature of land uses likely to affect the park's resources 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.

<u>Products</u>:

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.

HUMAN USE (ACTIVITIES) INVENTORYING AND MONITORING

Function	Level of Effort I	II	*III
A. EVENT RECORD			
1. Record unique or unusual anthropological events, such as migrations. effects of droughts, disease epidemics.................	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, fishing, recreation)................................	x		
2. Quantify the identified activities (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	

*Note to reader: There is no Level III.

Function	Level of Effort I	Level of Effort II
F. DOMESTIC ANIMALS		
1. Indicate number of individuals of livestock.	x	
2. Indicate number of livestock species, groups, herds, flocks, gaggles, etc.................	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 and quantify changes in natural systems and to determine statistically if they are caused by anthropogenic 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 anthropogenic factors are to be shown to be significantly altering natural processes. 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 (viz., G.I.S. technologies),
- ...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 are 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.

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 7.) 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 facilitate 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.

The technical Information Center (TIC) (located at DSC), in conjunction with NPS-29, is the Servicewide authority on labeling and repositing information. TIC is also the repository for aerial photography and should be consulted before one contracts for photography.