<u>DRAFT</u>

GUIDELINES

NATURAL RESOURCES INVENTORY AND MONITORING

FOR

THE NATIONAL PARK SYSTEM

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I. POLICY

The need to monitor natural resources in National Parks has been recognized and developed in public law, proclamation, and executive order since the inception of the national park System. A primary element of the natural resource mission of the National Park Service is to conserve unimpaired parks as dynamic vignettes of primitive America for the enjoyment of present and future generations (16 USC 1). The National Environmental Policy Act of 1969 clearly requires certain knowledge of resource conditions to direct and evaluate effects of management actions. The Forest and Rangeland Renewable Resources Planning Acts of 1974 and 1976 also express Congressional insistence on inventory and monitoring of natural resources on all public lands in the United States. Therefore it shall be the policy of the National Park Service to inventory and monitor natural resources in all units of the system. The magnitude of this effort will vary from unit to unit as described in these guidelines.

II. DEFINITIONS

NATURAL RESOURCE INVENTORY is the process of acquiring, managing, and analyzing information on park resources, including but not limited to the presence, distribution, and condition of plants, animals, soils, water, air, natural features, biotic communities, and natural processes.

NATURAL RESOURCE 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.

III. OBJECTIVES

Each individual national park unit Inventory and Monitoring (I&M) program must be designed and operated to accomplish specific and well documented objectives. Park I&M objectives should be an outgrowth of the ongoing natural resources planning process. In parks where natural zone lands predominate, the scope of the I&M effort will usually be broader than in those areas where the management of historic or special use zones are of primary concern. In these areas monitoring of natural resources may be directed at gaining an understanding of their inter-relationships with the historic or cultural features. In areas where public use and recreation is heavy, monitoring will be important to determine the impact of these uses on natural resources. The following general objectives should guide the selection of specific programs.

1. Determine present and future health of park ecosystems, or specific components such as individual species populations.

2. Define "normal" conditions and variations within natural systems or populations.

3. Define specific impacts or effects due to known human activities.

4. Identify potential agents of abnormal anthropogenic change.

5. Assist in the development of a better service and public understanding and appreciation of natural processes and the need for their protection.

III. PROGRAM DESCRIPTION

As large natural ecosystems, national parks have many values for modern society. In the beginning, national parks were conceived as pleasuring grounds for the people, to be preserved in their natural condition and protected from wanton destruction (16 USC 21-22). As the nation's manifest destiny was realized, Rousseau's wilderness "conquered," and Americans became urbanized, the national parks became islands of nature and were increasingly valued as emotional retreats from the stresses of modern life. Additional park values emerged as advances in biology revealed the mechanisms of heredity and an understanding of ecosystems and ecological processes developed in the mid-twentieth century. National parks are now recognized as reservoirs of wild genetic materials that are the basis of the nation's future in bio-engineering, agriculture, and pharmaceuticals. Perhaps most importantly though, as the potential adverse impacts of human activities on the global atmosphere have become more widely recognized and politically acknowledged at the close of this century, national parks have become "miner's canaries" for the biosphere. Natural systems in national parks provide the best indicators of ecological effects of anthropogenic perturbations such as acid precipitation, ozone depletion, and global warming. Conversely, they offer the best mechanisms for understanding natural environmental variations and for developing techniques and evaluating attempts to mitigate adverse impacts by providing empirical evidence of ecologic change.

Not all of the National Park Service's natural resources are found within the borders of the large national parks. Natural resources of considerable value are found in nearly all units of the system, including recreation areas, historic and cultural areas, seashores, etc. These resources may only represent fragmented or remnant ecosystems, however, because of their location near major metropolitan areas, and or because of heavy visitor use, they are of considerable importance to the American public. The monitoring of these resources is necessary in order to protect them from visitor impact and often to understand their relationship to the cultural, historical, and recreational resources to which they are closely linked.

In the larger national parks, healthy ecosystems maintain themselves, just like healthy people do. The role of the National Park Service is that of an ecological health maintenance organization. Like a family physician, the Service must: (1) determine when the park is sick by monitoring ecological health with regular checkups; (2) treat illness and repair damage; and (3) prevent illness by reducing exposure to harmful agents. A natural resource monitoring program must provide the same kinds of information to park managers that health monitoring provides to physicians. It must indicate current health, predict future conditions, be sensitive to subtle chronic stresses as well as identify overt lethal threats, and suggest effective treatments for disfunction. An effective monitoring program will also help identify causes of system disfunction in addition to identifying signs and symptoms.

To fulfill the National Park Service mission of preserving and protecting park resources, it is essential that park managers know the nature and condition of the resources in their stewardship, have the means to detect and document changes in those resources, and understand the forces driving the changes. To determine appropriate management actions, we must know what resources are held in trust, how they change over time, and how those changes are related to human activities. Natural resource inventories and monitoring are indispensable to determine fidelity to or deviation from desired resource conditions; to diagnose human impacts; to direct management intervention; and to measure subsequent success or failure of that intervention. Inventory and monitoring are fundamental elements of a National Park Service program that includes: (1) scientific investigations to elucidate the ecological and anthropogenic processes that drive park ecosystems; and (2) management of those systems and processes based on the information so acquired.

In addition to their diagnostic and dynamic baseline values, long-term time-series data sets which monitoring generates are also often required to establish cause and effect relationships, determine compliance with emission/discharge standards and regulations, or develop and evaluate mitigation of specific anthropogenic perturbations. Long-term studies to determine, regulate, or mitigate impacts need to be designed specifically for each application and are beyond the scope of the basic natural resources monitoring defined by these guidelines.

The specific ecosystem components to be monitored and the levels of accuracy and precision required will vary from park to park, but the fundamental reasons for monitoring in every park remain the same.

Staffing Requirements and Relationships

The design and implementation of an inventory and monitoring program must be a joint effort between the individual park system unit and cooperating scientists from either NPS ranks or contracted through local universities. Qualified scientists in a variety of specialized fields should have a major role in determining which specific ecosystem parameters will be measured and how this can best be accomplished. However, it is the park resource managers responsibility to assure that the program meets park objectives and that it is operationally feasible to carry out the program as designed by the science community. There needs to be a true partnership in this endeavor. The following is a suggested role and function statement for the various staff members involved in the total process.

Park, Regional, CPSU, or university scientists: These people should be responsible for recommending which ecosystem parameters need to be monitored and the measurement protocols. If this information is not available than they should design research to acquire this level of understanding.

Park Managers: Superintendents and regional managers need to understand the basic concepts of Inventory and Monitoring and assure that programs are developed that not only serve park needs but meet Servicewide I&M goals and objectives. Long-term base funding protection is necessary to insure program longevity.

Park Natural Resources Management Staff: In is very doubtful if a park unit could carry out an I&M program without at least one professional level natural resource specialist on the staff. The full involvement of professional resource managers in the planning and design phase is necessary to assure that protocols can reasonably be accomplished within the framework of existing budgets and staffing. Much of the implementation of the program will, by necessity, be the responsibility of these people. In very small units that have a limited need for natural resource I&M, some basic work could be accomplished by park rangers or interpreters that have a natural science education. The key to maintaining a scientifically-based and credibly I&M program through time is the continual efforts of highly qualified natural resource scientists, specialists, and managers.

Park Rangers and Field Maintenance Staff: This group of people usually contains the largest group of field staff in the park. When appropriate, their services can be used to assist in the protection and maintenance of the I&M system. Their input should be sought when designing the program so that the location of plots, transects, etc., and the methods used to collect data do not interfere with other areas of park operations. The locations of most plots should be generally known to these people so that they can be protected from visitor impacts and maintenance activities.

Park Interpretive Staff: The full involvement of the interpretive staff will benefit the park in many ways. Although it may not be wise to conduct interpretive walks to long-term monitoring sites unless site protection can be assured, it is important that interpreters are familiar with the program and have first hand knowledge of how data is collected and used. Information gained through the I&M program will be of considerable interest to the general public and organized environmental groups. Support for I&M funding can be greatly enhanced by informing the public and other interested parties of program accomplishments and insights gained. Interpreters should be encouraged to find new and innovative ways to maximize the public good that can be achieved by wide dissemination of information gained through these programs.

IV. INVENTORY AND MONITORING PROGRAM DESIGN

Design of a long-term ecological inventory and monitoring program begins with a conceptual model of the system to be monitored and managed. This model consists of an exhaustive list of mutually exclusive system components and a description of their relationships. From the list of components, representative elements may be selected and tested for monitoring, and the adequacy of existing resource inventories may be evaluated. Components should include all major biotic and abiotic resources and the processes by which they interact.

There are several legitimate ways to describe and monitor ecosystems. Among the more popular and potentially useful for long-term monitoring are biodiversity, energy flux, nutrient cycles, and population dynamics. Biodiversity is an important attribute of ecosystems that functions at many levels: genetic, individual, population, community, and even ecosystem. The repeated inventories required to measure and monitor biodiversity are expensive and difficult to conduct. They require highly skilled surveyors to identify the elements of diversity. Changes in diversity are difficult to assess and ambiguous to interpret in terms of system changes. They are also difficult to apply to management issues.

Energy flux provides a common currency for comparisons among system elements by reducing everything to kilocalories. Measurements of energy in ecosystems is often complex and difficult in the field, and frequently requires destructive sampling (e.g., estimating biomass in root systems). Changes in energy flux are also difficult to interpret in terms of system health and do not provide early warnings of impending problems.

Ecological limiting factors, such as nutrients and other chemical and geo-physical constituents, are also used to characterize ecosystems. Drawing on an important management principle, this approach to system monitoring selects a few critical control points in the system and evaluates the flow of selected constituents through those points. This approach requires an extensive a priori understanding of ecosystem structure and function, and as with energy flux, measurements are often complex and difficult to conduct in wilderness settings. The results are often ambiguous and difficult to interpret (e.g., acid precipitation and air pollution), but when knowledge of system structure and function are sufficient, constituent monitoring can provide excellent early warnings that may be directly applied to management issues because the cause and effect relationship was established a priori.

Population dynamics, the ways in which populations change, offer the best solution to monitoring the biological component of park ecosystems for the National Park Service. Parameters of populations like abundance, distribution, age structure, reproductive effort, and growth rate are easily measured, sensitive to subtle chronic stress, and project future conditions. This approach also reflects a wide variety of environmental conditions because organisms integrate effects of influences like predation, competition, and food condition, and express their responses as easily measured population parameters. Parameters such as age structure and reproduction permit projections of future conditions, providing early warnings of pending problems. Subtle, chronic stresses are reflected in reduced growth and reproductive rates. Interpretation of these parameters is direct and can be synthesized into system level applications, and most management controls operate at the population level, so application to management issues is direct and measurable.

The monitoring and recording of abiotic ecosystem components and events such as weather, fires, floods, streamflow etc. can be readily accomplished and provide a historical record of these factors. Such long-term records are often critical to the understanding of natural variations and catastrophic forces that have shaped the land.

Selection of Elements to be Monitored

As previously mentioned, the laundry list of species, populations, events, and processes that could be monitored is virtually endless. Therefore, a system of prioritizing the choices is needed. The following priorities are suggested, knowing that variations of these will be needed to meet individual park objectives.

Priority #1. Resources specifically mentioned in the park unit enabling legislation, listed as rare, threatened or endangered, or otherwise given special status by law.

Priority #2. Key ecosystem processes that can be well defined and accurately accessed.

Priority #3. Species or process that may impact on public health or safety or are locally controversial.

Priority #4. Events such as fire, flood, volcanic activity, erosion, weather patterns, etc.

Priority #5. Resources being threatened by visitor use.

Priority #6. Baseline monitoring of species, populations or compositions that enhance our understanding of particular phenomina, relationships or population dynamics.

Priority #7. Species or populations that are of interest but of no particular management or ecological concern.

BASIC MONITORING TECHNIQUES.

<u>Chemical and Geo-Physical Resource Monitoring</u>

Monitoring of chemical substances focuses on measurements of nutrient inputs and cycles, and detection of undesirable elements and compounds and their modes of transport into and through the system. Natural substances and pollutants are examined in the atmosphere, waters, soil, litter, detritus, and biota. Which substances will be monitored and the most appropriate methodology to employ will be determined on the basis of local conditions, but a list of important constituents and standards for their measurement are provided in Appendix A.

Biological Resource Monitoring

After dividing park resources into an exhaustive list of large, mutually exclusive, classical taxonomic categories, experts in each taxon are asked to select species that represented a broad array of ecological roles, with examples of many trophic levels and life forms from primary producers to top carnivores and sessile invertebrates to wide ranging birds and mammals. Species with legal status or specifically mentioned in park enabling legislation must be included, as well as endemics and aliens, harvested taxa, dominants characteristic of whole communities, common taxa, and heroic or charismatic species. Professional judgment is required to determine if existing resource inventories available in the scientific literature and park files are sufficient to identify system "vital signs," but most parks have enough information with which to proceed.

Short-term design studies can be conducted to assist in the selection of taxa and population parameters to meet program objectives. These studies will also be used to select and adapt or develop sampling techniques appropriate for each taxon and system, including geographical sites and sampling frequency.

Site selection is critical. It is important to put the thermometer under your tongue every time to get reliable body temperature readings, but it is not necessary to measure body temperature on a uniform grid all over your body to get an accurate reading. Monitoring locations need to be stratified to efficiently sample selected populations. Sites need to be representative of the entire system to be monitored, but it is too expensive to sample on uniform grids solely to satisfy GIS software requirements.

Event and Weather Monitoring

Many park areas already take basic weather measurements at one site. Events such as wildfire, storms, earthquakes, etc., are also frequently measured. The accuracy and precision of existing sampling techniques should be tested or otherwise evaluated during the protocol design period. Additional measurements deemed necessary to fully define the parameter will be added to the existing framework.

Data Management

Analytical protocols and report formats will be developed during design studies. A data management system is an essential part of the monitoring design process. Once field sampling is complete, raw data are recorded, archived, entered into computer programs that assist in summarizing information, and analyzed through lists, charts, tables, graphs, and statistical calculations as appropriate. Descriptive measures of population dynamics parameters are the ultimate result. Data analysis is accomplished using standard software (such as dBase III+, Lotus 1-2-3, SPSS PC+, and WordPerfect).

V. PROGRAM PLANNING

1. Develop a Conceptual Model of Park Ecosystems

    1.1. Set limits (boundaries) on the systems.

    1.2. Make an exhaustive list of mutually exclusive components within the established limits (break large system into understandable units).

        1.2.1. Determine appropriate geographic divisions, such as watersheds, habitats plant communities, physiognomic units, or landscapes.

        1.2.2. Determine appropriate taxonomic divisions, such as logical species, physical properties, and chemical species.

1.3. Identify relationships among system components and processes that affect them.

2. Conduct Design Studies

2.1. Select critical components (atmospheric chemicals, water quality, water flow, land birds, sea birds, land mammals, reptiles, amphibians, fish, invertebrates, weather, storms).

2.1.1. Establish selection criteria.

2.1.2. Apply criteria to all system components.

2.2. Set priorities on components.

2.2.1. Review appropriate legislation, executive orders, and policy.

2.2.2. Consider threats to park ecosystems.

2.2.3. Determine priority management information needs.

2.2.4 Review the knowledge base for each component, including taxonomy, natural history, and population dynamics.

2.2.5. Determine monitoring technology for each component, including accessibility, and proven methodologies (Do new techniques need to be developed?).

2.2.6. Consider the responsibilities and programs of other agencies regarding components.

2.3. Design monitoring protocols for each component.

2.3.1. Review scientific literature for each component, specifically obtain species lists, information on sampling methodologies, and historical data on component dynamics.

2.3.2. Select parameters of components to monitor: species, population parameters, constituents.

2.3.2.1. Assure selected species and constituents are representative of the component: all trophic levels, reproductive strategies, life spans, and ontogenetic cycles.

2.3.2.2. Include special status species (i.e. threatened and endangered, marine mammals, etc.), park endemics, aliens, harvested taxa, community dominants, and "heroic" or "charismatic" species.

2.3.3. Select, or develop, and test data acquisition systems for accuracy, precision, and representativeness.

2.3.4. Establish a data administration system, including networks and a geographic information system.

2.3.5. Prepare standardized report formats and a formal mechanism for reviewing and document changes in monitoring protocols.

2.3.6. Demonstrate efficacy of protocol through at least one year of actual operation.

3. Place System in Operation

3.1. Obtain base-funding.

3.1.2. Solicit and gain support from park staff and interested and/or influential public.

3.1.3. Establish accountability for knowing the condition of park resources (ecosystem health) from the top of the organization down to the field level.

3.1.4. Obtain broad program review and approval from scientific community (National Academy of Sciences, National Science Foundation, other agencies) and NPS Management (Superintendents and Regional and National Directorates).

3.2. Obtain personnel.

3.2.1. Determine knowledge and skills required.

3.2.2. Prepare position descriptions and performance standards.

3.2.3. Recruit and hire personnel.

3.2.4. Establish career ladder and training program.

3.3. Implement monitoring protocols.

3.4. Synthesize information on each component into annual status report on ecosystem health and test null hypothesis that the system has not changed from previous conditions.

3.4.1. Determine historical or estimated values and variations for each system, component, and parameter.

3.4.2. Compare current values to historical values and variations.

3.4.3. Examine values and variations for correlated patterns in space and time with other components, events, and threats.

<u>Program Documentation and Reporting</u>

Resource monitoring is not complete when the field observations and data analysis have been made. A long-term monitoring program must adapt to changes in environmental conditions and take advantage of changing technology and knowledge without losing the continuity and integrity of the data record. The establishment of a reporting procedure is therefore an important step in the monitoring design process. As part of reporting procedures, the format is defined, appropriate audience and distribution is determined, and review procedures and standards for review are established. An annual summary report documenting the condition of park resources will be developed. Standards and guidelines that assist authors and reviewers in organizing their thoughts and comments and to assure some consistency in the reports are provided in Appendix B. The reports are edited by two National Park Service research scientists, an academic (or other agency) subject area scientist, and an editorial review board composed of the park superintendent and division chiefs for resource management, ranger activities, and interpretation. The reports serve as a repository for monitoring observations, a vehicle for disseminating information locally, and a mechanism for documenting management recommendations, including changes in monitoring procedures. Reports are generally prepared each year at the end of the field season by the resource manager responsible for each ecological component that is monitored.

Monitoring protocols for each park will be documented in handbooks for each ecological component monitored. Handbooks institutionalize monitoring and allow many observers to continue the monitoring process over the long term by describing data collection and analysis techniques in detail. In this way, continuity and quality of future data collection by resource managers can be maintained. As field methods are further tested and experience allows for new insights, park handbooks will be reviewed and revised. The annual report provides a mechanism for reviewing and making recommendations for revisions in the handbooks.

VII. PROGRAM MAINTENENCE

VIII. PROGRAM EVALUATION