STRATEGY FOR DESIGNING ECOSYSTEM MONITORING PROGRAMS TO TRACK CONDITIONS OF NATURAL RESOURCES IN NATIONAL PARKS

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SUMMARY
National Park managers in the United States are directed to preserve “unimpaired for future generations” the air, water, geological and biological resources of the park, as well as the various ecological processes that created the park and continue to act upon it. Natural resource monitoring provides site-specific information needed to understand and identify change in complex, variable, and imperfectly understood natural systems and to determine whether observed changes are within natural levels of variability or may be indicators of unwanted human influences. Thus, monitoring provides a basis for understanding and identifying *meaningful change* in natural systems characterized by complexity, variability, and surprises. As a major component of the Natural Resource Challenge, approximately 270 parks with significant natural resources are in the process of planning and designing an integrated ecosystem monitoring program to provide a broad-based understanding of the status and trends of park resources. The strategy for implementing long-term ecological monitoring throughout the National Park Service involves 11 experimental or “prototype” monitoring programs begun in 1992, and 32 “vital signs monitoring networks” of parks linked by geography and shared natural resource characteristics. Parks within each of the 32 networks work together and share funding and professional staff to plan, design and implement an integrated long-term monitoring program. The complex task of developing a network monitoring program requires a front-end investment in planning and design to ensure that the program meets the most critical information needs of each park, makes maximum use of leveraging and partnerships with other agencies and academia, and produces scientifically credible data that is accessible to managers, researchers, and educators.

1. ECOLOGICAL MONITORING AND NATIONAL PARK STEWARDSHIP

Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making aimed to maintain, enhance, or restore the ecological integrity of park ecosystems and to avoid, minimize, or mitigate ecological threats these systems (1). Knowing the condition of natural resources in national parks is fundamental to the National Park Service’s ability to manage park resources "unimpaired for the enjoyment of future generations." National Park managers across the country are confronted with increasingly complex and challenging issues that require a broad-based understanding of the status and trends of park resources as a basis for making decisions and working with other agencies and the public for the benefit of park resources. For years, managers and scientists have sought a way to characterize and determine trends in the condition of parks and other protected areas to assess the efficacy of management practices and restoration efforts and to provide early warning of impending threats. The challenge of protecting and managing a park's natural resources requires a multi-agency, ecosystem approach because most parks are open systems, with threats such as air and water pollution, or invasive species, originating outside of the park's boundaries. An ecosystem approach is further needed because no single spatial or temporal scale is appropriate for all system components and processes; the appropriate scale for understanding and effectively managing a resource might be at the population, species, community or landscape level, and in some cases may require a regional, national or international effort to understand and manage the resource. National parks are part of larger ecosystems and must be managed in that context.

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observed changes are within natural levels of variability or may be indicators of unwanted human influences. Thus, monitoring provides a basis for understanding and identifying meaningful change in natural systems characterized by complexity, variability, and surprises. Monitoring data help to define the normal limits of natural variation in park resources and provide a basis for understanding observed changes; monitoring results may also be used to determine what constitutes impairment and to identify the need to initiate or change management practices.

2. STRATEGY FOR NATURAL RESOURCE MONITORING IN NATIONAL PARKS

The strategy for implementing long-term ecological monitoring in approximately 270 parks in the U. S. National Park Service that contain “significant natural resources” involves two components: 11 experimental or “prototype” monitoring programs begun in 1992, and 32 “vital signs monitoring networks” of parks linked by geography and shared natural resource characteristics. The level of monitoring conducted by prototype programs is both more comprehensive and more intensive than what other parks will be able to undertake. Prototype monitoring programs are responsible for assisting in the design, development, and testing of monitoring protocols and methods and for providing instruction in the use of those products to other parks occupying similar ecological settings. The prototype programs possess a wealth of experience and expertise related to the development and implementation of ecological monitoring that can greatly benefit other parks throughout the Service, and provide technical assistance to staff from other parks on a wide variety of technical issues related to monitoring, including conceptual design, database management, data integration and analysis, and reporting of monitoring findings. Parks within each of the 32 vital signs monitoring networks work together and share funding and professional staff to plan, design, and implement an integrated long-term monitoring program. Each of the 32 park networks is guided by a board of directors (usually comprised of park superintendents and the regional and network coordinators) which specifies desired outcomes, evaluate performance for the monitoring program, and promote accountability. The level of funding available through the Natural Resource Challenge will not allow comprehensive monitoring in all parks, but will provide a minimum infrastructure for initiating natural resource monitoring in all parks that can be built upon in the future.

The intent of park vital signs monitoring is to track a subset of physical, chemical and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological and physical processes that act on those resources. In situations where natural areas have been so highly altered that physical and biological processes no longer operate (e.g., control of fires and floods in developed areas), information obtained through monitoring can help managers understand how to develop the most effective approach to restoration or, in cases where restoration is impossible, ecologically sound management. The broad-based, scientifically sound information obtained through natural resource monitoring will have multiple applications for management decision-making, research, education and promoting public understanding of park resources.

During the development of the vision for park vital signs monitoring, it was clear that a "one size fits all" approach to monitoring design would not be effective in the NPS considering the tremendous variability among parks in ecological conditions, sizes and management capabilities. A primary purpose of vital signs monitoring is to provide park managers with the data they need to understand and manage park resources, and the data most relevant to different types of park systems should be expected to be very different. Furthermore, partnerships with federal and state agencies and adjacent landowners are critical to effectively understand and manage the many resources and threats that extend beyond park boundaries, but these partnerships (and the appropriate ecological indicators and methodologies involved) differ for parks throughout the national park system.

The amount of funding available for vital signs monitoring allows most parks to monitor only a few indicators. The NPS has adopted a strategic approach to maximize the use and relevance of the monitoring data at the park level by allowing each network of parks to determine what they will monitor based on their most critical data needs and local partnership opportunities. Parks are encouraged to use or modify standard protocols and partner with existing programs wherever possible to allow comparability and synthesis of data, and the servicewide monitoring program will coordinate the development of standardized protocols and approaches where appropriate, but decisions on what should be monitored and the most appropriate protocols to follow are made at the network level.

The list of ecological indicators monitored throughout the National Park System is expected to follow the "wedding cake design" adopted from the USDA Forest Service, in which the majority of indicators are selected to provide site-specific data need by park managers for making decisions and working with other agencies and individuals for the benefit of park resources. Nationwide, or at the level of the park network or ecosystem, there is also a set of indicators that are monitored in a standardized way to allow comparisons and synthesis of data across larger areas.

3. GOALS OF VITAL SIGNS MONITORING

To guide the monitoring program, all 32 park networks address the following five goals as they plan, design, and implement integrated natural resource monitoring:

- Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- Provide a means of measuring progress towards performance goals.

An effective long-term ecosystem monitoring program will:

- Enable managers to make better informed management decisions;
- Provide early warning of abnormal conditions in time to develop effective mitigation measures;
- Provide data to convince other agencies and individuals to make decisions benefiting parks;
- Satisfy certain legal mandates; and
- Provide reference data for comparison with more disturbed sites.

4. RECOMMENDED APPROACH FOR DESIGNING A NETWORK MONITORING PROGRAM

The complicated task of developing a network monitoring program requires an initial investment in planning and design to guarantee that monitoring meets the most critical information needs of each park and produces scientifically credible results that are clearly understood and accepted by scientists, policy makers, and the public, and that are readily accessible to managers and researchers. These front-end investments also ensure that monitoring will build upon existing information and understanding of park ecosystems and make maximum use of leveraging and partnerships with other agencies and academia.

Each network of parks is required to design an integrated monitoring program that addresses the monitoring goals listed above and is tailored to the high-priority monitoring needs and partnership opportunities for the parks in that network. Although there will be considerable variability among networks in the final design, the basic approach to designing a monitoring program should follow five basic steps:

1. Define the purpose and scope of the monitoring program (establish goals and objectives);
2. Compile and summarize existing data and understanding of park ecosystems;
3. Develop conceptual models of relevant ecosystem components;
4. Select indicators and specific monitoring objectives for each; and
5. Determine the appropriate sampling design and sampling protocols.

The recommended sequence of steps involved in designing an integrated monitoring program for a network have been incorporated into a three-phase planning and design process. The recommended approach is described in documents available on the National Park Service “Monitoring Natural Resources in our National Parks” website, at http://www.nature.nps.gov/im/monitor. Phase 1 of the planning and design process involves defining goals and objectives; beginning the process of identifying, evaluating and synthesizing existing data; developing draft conceptual models to help organize and communicate information; and completing other background work that must be done before the initial selection of ecological indicators. Each network is required to document these tasks in a Phase 1 report, which is then peer reviewed and approved at the regional level before the network proceeds to the next phase. Phase 2 of the planning and design effort involves prioritizing and selecting vital signs and developing specific monitoring objectives for each that will be included in the network's initial integrated monitoring program. Phase 3 entails the detailed design work needed to implement monitoring, including the development of sampling protocols, a statistical sampling design, a plan for data management and analysis, and details on the type and content of various products of the monitoring effort such as reports and websites.

The task of selecting a few ecological indicators for a national park that "represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values" is extremely difficult. It is relatively easy to generate a list of potential monitoring projects or indicators to address a park's most critical data needs, but the process of paring the list down to a few "vital signs" that best represent the composition, structure, and function of the larger ecosystem is very challenging. Most networks of parks are following the basic approach depicted in Figure 1 to identify and prioritize potential vital signs. The scoping process usually involves a series of meetings, workshops, brainstorming sessions, questionnaires, literature reviews, and other information-gathering exercises to identify monitoring questions and data needs that include (1) focal resources (including ecological processes) important to each park, (2) agents of change or stressors that are known or suspected to cause changes in the focal resources over time; and (3) some basic key properties and processes of ecosystem health (e.g., weather, soil nutrients). Conceptual models are then developed to help organize and communicate the information compiled during scoping, and to identify where cause-effect is known between some of the stressors and response variables. The scoping and conceptual modeling efforts will result in a list of potential vital signs, which must then be prioritized using a structured, group decision-making process to determine the network's "short list" of vital signs that will be included in the initial monitoring program.

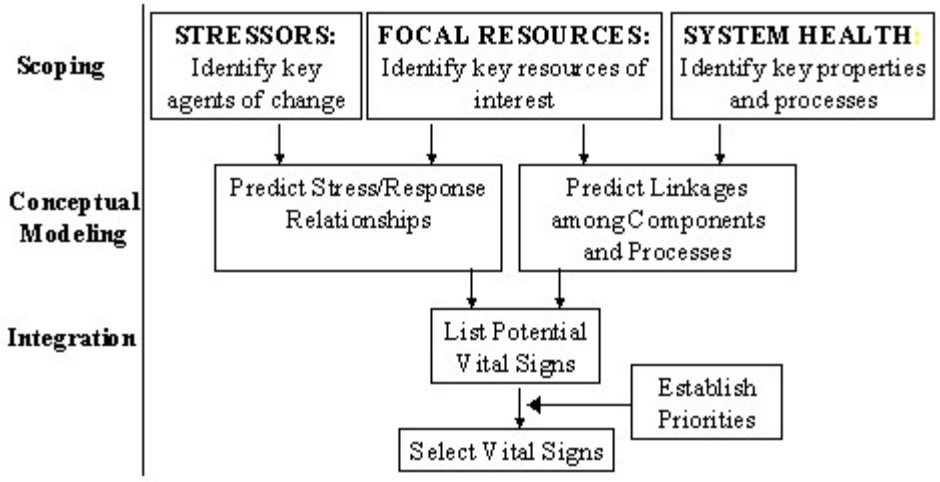

Figure 1. Basic approach to identifying and selecting vital signs for integrated monitoring of park resources (source: Kurt Jenkins, U.S. Geological Survey, Olympic Field Station).

During the past two years, park networks involved in planning and design of monitoring programs have received assistance from numerous federal and state agencies, non-governmental organizations such as NatureServe, private contractors, the Cooperative Ecosystems Studies Unit network, and academic scientists from more than 100 universities. The efforts by these networks to develop an integrated, systems-based monitoring program have catalyzed the development of a number of interagency partnerships. The vital signs monitoring networks are a central component of natural resource stewardship as the National Park Service embraces the concepts of “Parks for Science” and “Science for Parks.”

REFERENCES

1. C. T. Roman and N. E. Barrett. 1999. Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore. U. S. Geological Survey, Patuxent Wildlife Research Center. Available at http://www.nature.nps.gov/im/monitor/caco.pdf