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Inventory and Monitoring in the National Parks: Forging a Plan

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The National Park Service will assemble baseline inventory data describing the natural resources under its stewardship and will monitor those resources ... to detect or predict changes. The resulting information will be analyzed to detect changes that may require intervention and to provide reference points for comparison with other, more altered environments [emphases added].

— Management Policies, Chapter 4.4, 1988

The NPS policy statement above marks a turning point in the long history of resource inventory and monitoring in national parks. For although inventory and monitoring (I&M) activities — species checklists, visitor counts, weather records — have been conducted in individual parks since the 1870s, only recently has there been an effort to establish a more rigorous and integrated approach to these endeavors. The impetus behind this effort is threefold. First, multiple environmental stresses on parks (including human use, air pollution, introduced species, and a changing global climate) are increasing at an unprecedented rate, making reliable scientific data imperative for effective resource management. Second, there is a growing recognition that coordinating and standardizing I&M activities throughout the NPS would enable managers to track resource conditions on an interpark and nationwide basis, ultimately yielding a higher quality of both I&M data and managerial decision-making. Finally, it is generally acknowledged that for I&M programs to be successful in the long term, the responsibility for coordinating these activities must be tied to positions rather than individuals: they must be incorporated into the NPS organizational structure.

While the NPS is committed to the concept of improved inventory and monitoring, there have been no systematic guidelines until now (see shaded box). Resource managers also need a standardized planning strategy to help them in developing individual park I&M programs. The planning strategy should 1) be generic enough to accommodate a variety of objectives and resolution levels, 2) assist managers with decision-making, including improved quantification, and 3) be flexible enough to be easily modified and updated. The development of such an approach is part of an ongoing research effort by the Pacific Northwest Region to improve I&M programs in the NPS. Research Biologist David L. Peterson and Research Associate David L. Silsbee are directing this effort at the U/WA CPSU, in cooperation with Daniel L. Schmoldt of the USDA Forest Service, Blacksburg, VA. The planning approach developed by this research team emphasizes the following components:

This article (the first in a series of two) represents a research effort on the part of the Pacific Northwest Region to offer an approach for developing a dynamic, technically rigorous inventory & monitoring program within each park. Based on state-of-the-art methods and analyses, it offers practical strategy and support tools that will facilitate I&M program development among parks. One sign of NPS's renewed commitment to I&M is the recent appointment of Gary Williams to the newly created position of Director of the Service-wide Inventory & Monitoring Program at WASO. A general conceptual model of the inventory and monitoring process appears in the recently published *Natural Resources Inventory & Monitoring Guideline* — NPS-75. For more information, contact Gary Williams, (202) 208-5193.

- An interdisciplinary team approach to I&M program development
- Standardized project description and classification
- Development strategy: objectives and attributes of I&M projects
- Quality assurance and data management considerations
- Support tools for prioritizing, planning, and allocating resources to I&M projects.

This approach can be used to develop a new I&M program or to modify an existing one. The **interdisciplinary team** of scientists and resource managers would work together intensively to develop program objectives and write a comprehensive I&M plan for the individual park. Standardized **project descriptions** and **classifications** establish a conceptual and technical basis for prioritization and implementation, as well as insuring consistency among parks. **Development strategy** for I&M programs focuses on the objectives and attributes of each project as the keys to implementation. **Quality assurance** and **data management considerations** are addressed as essential factors in maintaining the integrity and scientific validity of each proposed I&M program. Finally, the **support tools** consist of decision-making strategy (the Analytic Hierarchy Process) and interactive computer software, both of which employ a quantitative rating system to assist in planning and prioritizing I&M projects. The same tools serve in the allocation of resources for I&M projects, which is optimized by including information on budget and personnel requirements as part of evaluating and selecting projects. *This final section on I&M support tools will appear in the next issue of Park Science.*

Interdisciplinary Planning: the Team, the Tools, the Process

One of the most useful innovations in the works is the development of an I&M interdisciplinary planning

Continued on page 3

Figure 1. Interdisciplinary team process for developing an I&M plan.

I. INITIATION OF PROCESS: Park staff

Contact I&M team leader;
provide materials

II. WORKSHOP: I&M team & park staff

Overview; brainstorming;
final project list; descriptions

III. I&M PLAN DRAFT: I&M team leader & park staff

Compilation of project descriptions;
overview; tables; references

IV. REVIEW: I&M team, park staff, & others

Circulation of draft for review

V. FINAL I&M PLAN: I&M team leader & park staff

Final plan written, after reviews

team at the regional level. Composed of regional office personnel, field unit resource managers, and scientists from CPSUs – as well as experts from outside sources – the team would bring a wide range of professional knowledge to park I&M planning efforts. Working through a five-step process, team members would help resource management staff conduct a thorough review of the management and scientific aspects of I&M projects for the park, while keeping in mind the broader goals of the region and the NPS. Typically, the region's I&M coordinator (already in place or soon to be named in most regions) would be the team leader, overseeing a 10-member group with proven expertise in areas such as terrestrial, aquatic, and wildlife biology, social science, cultural resources, and resource management. One or more team members would also be proficient in quality assurance procedures and data management; other experts would be invited to participate as needed.

As indicated in Figure 1, the initiative to begin the process would come from the park's own resource management staff. On anticipating the need for developing (or revising) an I&M plan, the park's I&M coordinator (i.e., the resource manager with lead responsibility for I&M activities) would contact the regional I&M team leader, also providing the team with enough background material to establish a working familiarity with the park's resources, existing data, and current concerns. The park staff would then convene a workshop, preferably on-site, attended by the I&M team and selected members of the resource management staff. Following an overview, conducted by park staff on resources, scientific issues, and managerial concerns, including field site visits, the team leader would direct workshop participants through these phases: a brainstorming session to voice and record all ideas relevant

to I&M concerns; organizing a list of potential I&M projects; establishing a final, consensual list of I&M projects; and writing a detailed description of each proposed project. The team leader also would introduce planning and decision support tools, including the Analytic Hierarchy Process and related software, and would demonstrate applications for prioritizing projects and optimizing resource allocation.

At this point, park staff participants would be encouraged to draw on the available expertise for rating projects. These ratings would serve as input for park resource management staff, who would have the final word on project prioritization. Following the workshop, the team leader would compile completed project descriptions into a draft I&M plan, including a table of projects with estimated budget and personnel requirements, reference material, and an overview statement prepared in conjunction with park staff. This draft plan would then be circulated for review among the I&M team, park staff, and other appropriate NPS staff. Other interested parties, such as agencies with adjacent land ownership, also would be included in the review process. After consideration of these reviews, the final I&M plan would be prepared by the I&M leader and park staff.

In essence, the interdisciplinary planning group would serve as a "SWAT team," bringing in expert knowledge and tactics to expedite the process and enable resource managers to design I&M programs with the greatest efficiency, consistency, and suitability.

Project Description and Classification: Finding A Common Language & Organizational Framework

The list of projects developed by the interdisciplinary team must include enough data for each project to provide a conceptual and technical basis for prioritization and implementation. Moreover, individual project de-

scriptions must use a common language in order to guarantee consistency among parks and optimal usefulness within the NPS. To this end, Peterson et al. (1992) have developed a taxonomy of resource categories to be used in I&M planning. At the most general level, the categories consist of headings such as "Atmospheric," "Geologic," "Hydrologic," "Flora," "Fauna," and so on. Subcategories lend further precision, so that the full resource classification for one I&M project might read "Human Activity > recreation > backcountry use > impacts > aquatic resources," with the final subcategory being the most specific, and the full sequence representing a precise picture of the resource in question. Along with taxonomic classification, each project also is classified according to "level of effort" – the amount of effort required to obtain the information required for I&M planning. The three specific levels of effort are: 1) compile existing information, 2) conduct resource inventories, and 3) establish monitoring.

The current as well as the planned level of effort should be indicated. For example, a park that wishes to determine the effects of air pollution on plant species may already have some data on sensitive species (*current*: "compile existing information"), but would like to determine if other sensitive species are present (*planned*: "conduct resource inventories") and evaluate visible symptoms for several years (*planned*: "establish monitoring"). The first level, "compile existing information," does not actually involve any inventory or monitoring of resources. It is nevertheless important both because it prevents wasting time and money collecting information already available and because it provides clues to gaps in data that an I&M project typically encounters. For a full discussion of the specific methods involved at each level of effort, see Peterson et al. (1992). The resource categories and level of effort designations should be considered an organizational framework for classifying and identifying I&M projects in preparation for the subsequent steps of prioritizing, decision-making, and allocating resources.

Development Strategy: Defining Objectives and Selecting Attributes

The first hurdle in developing an I&M program is defining objectives. Only then can decision-makers move on to deciding which attributes (e.g., air quality, species) to inventory and monitor, and which monitoring protocols to apply. The most common objective is to use I&M information to enable managers to make better informed management decisions. For example, the impact of park visitors on vegetation can be monitored to determine whether changes in visitor management strategies are needed. Another typical objective would be to use I&M information to convince others to make decisions benefiting parks. As shown in Figure 2, the list of major I&M objectives extends to eight, and each of these can be described in concise, functional terms (e.g., "Inform internal decision-makers"). Figure 2 also delineates the relationship between each objective and its respective attributes selection.

Decisions regarding which specific attributes to monitor, and at what level the monitoring should be done, are determined by the governing objective. Inventory and monitoring can be done at any level, from individual organisms to entire ecosystems. A program with the objective of providing early warnings for global or regional problems, for instance, would require focusing on stresses appearing at the individual and

Figure 2. I&M Objectives and Attributes Selection

Objectives	Attributes Selection
Inform internal decision makers	Attributes involved in specific management decisions
Influence external decision makers	Attributes most likely to show effects of outside activities
Satisfy legal requirements	Determined by legal requirements
Maintain familiarity with resources	Attributes most sensitive to change
Provide better understanding of resources	Broad spectrum of attributes
Provide background information	Attributes of day-to-day interest to visitors and others
Provide early warning of global or regional problems	Attributes most likely to show detectable change
Provide background data for exploited areas	Attributes of interest in managing outside areas

Continued on page 4

I&M in National Parks

Continued from page 3

population level, where these effects would appear sooner than at the community or ecosystem level. Determining which species to monitor involves yet another set of criteria and considerations (for specifics, see Silsbee and Peterson (1991)). Developing specific monitoring protocols for selected ecosystem attributes is relatively straightforward, dictated by cost limitations and the intensity of sampling needed to give useful results.

Throughout this decision-making process, the development of an I&M plan can be expedited and enhanced by using the Analytic Hierarchy Process and the supporting software, Expert Choice¹ (these support tools will be discussed in depth in the subsequent article). Placing the objective (or "goal") at the top of the hierarchy, managers – with the help of the I&M team leader and Expert Choice – can change values randomly or systematically to see how changes in the objective would shift priorities down the line. For example, the relative importance of "support of resource management decision-making" could be high in one case and low in another. Or an emphasis on "provide background information" could be replaced by an emphasis on "satisfy legal mandates." This exercise enables a manager to determine how different management objectives would affect overall project rankings: changing just one element of the hierarchy might cause one project to rise, and another to drop, within the I&M program as a whole. The large and varied amount of information encompassed by the Analytic Hierarchy Process/Expert Choice model structure thus permits a resource manager to examine the conceptual basis for I&M project development and prioritization from many angles, and in great detail.

Quality Assurance and Data Management Considerations: Preserving the Integrity of the Program

A strong quality assurance (QA) program is the cornerstone of credibility for I&M efforts and insures that I&M data will stand up in a court of law, if necessary. QA provides continuity and consistency over time, among different employees, and through changes in management and personnel. This is particularly crucial for monitoring programs which compare data collected by a variety of people over a long period of time. In the context of an I&M program, QA focuses on the design of a program appropriate to the stated objectives, including the identification and resolution of potential quality assurance problems. Specialized experimental designs may or may not be necessary, but thorough documentation of project objectives, design, and methods is always vital to a QA program. Documentation of the precision and accuracy of all measurements used in I&M activities also is essential.

Each park's I&M coordinator must be aware of QA

concerns and address them explicitly. It is advisable to work with a statistician (as part of the I&M team, or brought in separately) concerning study design, sampling, and statistical analysis. Similarly, scientists with expertise in QA should be contacted for help in developing protocols for the park's I&M projects. Advice on specific QA protocols can be obtained through NPS divisions such as the Air Quality and Water Quality Divisions; other agencies, particularly the EPA, also have expertise in this area.

Every I&M project should include a QA document that correlates with the other elements of the overall I&M plan. The QA plan should include 1) a *description* that explains and justifies the overall approach to the project, including objectives, methods, scope, statistical treatment, and the project's relationship to other studies; and 2) a *methods manual*, including site selection, sampling protocols, data sheets, documentation of precision and accuracy, and data analysis and reporting. Careful documentation must continue throughout the duration of each I&M project, and should include: site descriptions and observations; explanations of deviations from sampling methods; sampling dates and personnel; periodic precision and methods checks of all methods and personnel; and data storage, including frequent duplication and security measures.

Sound data management measures, in turn, are the key to successful QA. The objectives of data management are to insure that 1) data are stored and transferred accurately, and 2) data are secured from loss or damage. Moreover, the structures and format of the data must be documented with sufficient detail so that someone not versed in the original project could interpret their meaning and evaluate their accuracy and precision. For recommended data management measures, see Peterson et al. (1992).

Although the QA and data management aspects of I&M can sound burdensome, they are critical to making a park's I&M program technically sound, credible, and defensible. If such measures are instituted at the start of each I&M project, they will become a routine part of its operation. Because every park unit will not have the expertise to develop QA and data management procedures on its own, it is vital to identify cooperators who have background in this area; this includes personnel from other parks or regional offices and various NPS divisions, as well as from other agencies and universities. Such outreach efforts can open doors to cooperators who would be interested in participating in I&M projects, and can also add facets to the program that the park itself cannot fund. Ultimately, the completeness of QA and data management must be balanced against available funding and labor.

A Commitment to I&M: Envisioning the Future

The practical strategy and support tools being developed by the Pacific Northwest Region offer an approach for developing an adaptable, technically rigor-

ous program within each park, based on up-to-date methods and analyses. They provide a consistent framework that will assist in standardizing I&M program development among parks on a regional and national basis. In addition, this approach encourages interaction among different units within and outside NPS, in order to address a wide range of scientific and managerial concerns.

The most striking sign of NPS's growing commitment to I&M is the newly created position of Servicewide Inventory & Monitoring Program Director at WASO. As Program Director, Gary Williams has helped to produce the newly published *Natural Resource Inventory and Monitoring Guideline, NPS-75*. When asked to define the driving force behind current I&M efforts, Williams quotes from the new *Guideline*: "Preserving the natural resources (and natural processes) in the National Parks may be the most important legacy the Park Service can provide American conservation."² In fact, a comprehensive NPS resource I&M program would be unique among such programs in the U.S. and throughout the world. Current programs outside NPS either monitor a wide variety of ecological parameters within small areas (as in experimental forests) or apply a narrow suite of measurements across large areas or networked sites for specific data needs (as in acid precipitation monitoring). The envisioned NPS program would apply a broad spectrum of ecological measurements to a large and diverse area. Moreover, information gleaned from I&M data would be valuable to many research programs that address issues within NPS and beyond, such as the Global Change Research Program. Successful development and administration of an I&M program of the magnitude presented here would provide a model for other agencies and institutions. In this way, NPS can seize the opportunity to be a national and global leader in I&M planning.

Tradenames are used for information purposes only. No endorsement by the U.S. Department of the Interior is implied.

¹ *Natural Resources Inventory and Monitoring Guideline, NPS-75.*

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The following publications are available from the Cooperative Park Studies Unit, AR-10, University of Washington, Seattle, WA 98195:

Peterson, D.L., D.G. Silsbee, and D.L. Schmoedt. 1992. *Guidelines for developing inventory and monitoring plans in national parks.* Manuscript submitted for publication.

Schmoedt, D.L., D.L. Peterson, and D.G. Silsbee. 1992. *Strategic inventory and monitoring programs: prioritizing projects and allocating expenditures.* Manuscript submitted for publication.

Silsbee, D.G., and D.L. Peterson. 1991. *Designing and implementing comprehensive long-term inventory and monitoring programs for National Park System lands.* Natural Resources. Rep. NRR-91/04. National Park Service, Denver, CO.