

Integration of Science & Management

A Framework for I&M Networks and Parks in the Intermountain Region

Introduction

This document serves as the central guiding vision and framework for the Intermountain Region I&M Networks for improving the integration of monitoring and resource management in national parks.

Vision for Intermountain Region I&M Networks: In accordance with the service-wide I&M program and the National Park Service mission, the Intermountain Region I&M networks will provide natural resource inventory and monitoring information that can be incorporated into park planning, management, and decision making processes. I&M network staff will work with managers to adaptively integrate information and knowledge gained from research, monitoring, and management experience to support relevant planning and facilitate making informed decisions about the resources entrusted to our care.

Background: In the latter third of the 20th century, National Park Service managers were roundly criticized for viewing science “with anything from benign neglect to outright hostility” (Kaiser 2000). The catalyst for change may have been the 1997 publication of Richard Sellars book, *Preserving Nature in the National Parks*, a scathing critique of science in the parks. Even after significant Congressional action in 1998 (National Parks Omnibus Act), which provided the NPS “its first clear mandate to support and conduct research” (Parsons 2004), and initiation of the Natural Resource Challenge in 2000, the NPS Advisory Board in its July 2001 report, “Rethinking the National Parks for the 21st Century”, still noted the following:

“Debate over the lack of science-based resource management continued [since 1963], but the Park Service made little progress during the last three decades in acquiring solid knowledge about park resources. Though criticism for this omission has mounted, science still takes a back seat in the parks.”

OVERVIEW



NPS Photo

As a result of these and other stimuli (e.g., the “Parks for Science, Science the Parks” initiative), the Natural Resource Challenge has been funded by Congress since 2000, bringing science (resource inventories, monitoring and applied research) back into parks. But ecological monitoring does not, in itself, improve stewardship of park natural resources. Scientific information must be integrated into resource management and resource management must inform the planning of monitoring efforts to facilitate science-based decision-making. Based on the experience of the Service and similar efforts by other agencies (Noon 2001), this may be the most daunting and important step in attaining the goals of the Natural Resource Challenge and the core mission of the National Park Service.

Objective: To provide a strategy and framework for integrating science, including research and monitoring, and management, including resources planning and management decision making processes.

Strategy: To be successful, it is necessary to take actions that will result in improving the integration of science, resource monitoring, and natural resource planning and management. To be effective across the Intermountain Region will require approaches as diverse as the resources and administrative mechanisms of the NPS units comprising the IMR inventory and monitoring networks:



- Explicitly linking NPS science programs and management in their objectives and processes;
- Identifying the institutions and approaches for linking these elements based on critical needs;
- Expanding or creating new partnership between park managers and scientists; and
- Providing a framework and strategy for adaptively learning and applying new information and knowledge that effectively:

- o Improves communication and the sharing of knowledge between scientists and managers;*

- o Incorporates management experience and needs into guiding research and monitoring efforts in parks;*

- o Incorporates knowledge gained through research and monitoring into park resource planning, management, and decision processes.*

- o Engages internal and external partners in achieving vision and goals of the Natural Resources Challenge*

Framework: The framework will be structured around opportunities for improving communication between science and management, incorporating management needs into monitoring, incorporating monitoring results into management, and promoting the roles and responsibilities of scientists and managers, the I&M program, CESUs, Research Learning Centers (RLCs), and internal and external partners. Framework products and processes will be developed and provided by cooperating programs and partners. These products and tools for integrating monitoring and management include:

- Conceptual ideas supported by knowledge
- New and existing approaches and techniques for learning
- Real and hypothetical examples of applications with observed or expected outcomes
- Examples of applications from other agencies or partners
- Experimental designs to test expected outcomes

Strategy and Framework

I. Communication

Integration Goal: *To improve communication and the sharing of knowledge between science and management.*

Barriers to information – NWFP example

- 1) Breaking down Language Barriers
 - a) Clear definitions of monitoring & adaptive mgmt terms (here or earlier in document) and avoidance of jargon
 - b) Conceptual diagrams as a means of disciplinary-neutral communication
 - c) Implementing communication strategies
- 2) Hierarchical and Targeted Information Delivery
 - a) Natural Resources Report Series
- 1) Examples; TUMA Inventory Report, others
 - b) Management briefs
 - 1) Web-based
 - 2) Written
 - 3) Face to Face
 - c) Annual Monitoring Summaries
 - d) Periodic Synthesis Reports
- 3) Science Communication and Education in NPS (Examples)
 - a) Establishing organizational structures and dynamics that engage scientists in NPS planning processes.
 - b) Using network operational structure to support feedback processes from science and monitoring results to park management – enhanced role of TC?
 - c) Using synthesis teams composed of managers and scientists to develop options for adjusting resource management and monitoring practices, when adjustments are indicated by monitoring and research.

II. Incorporating Management Needs into Ecological Monitoring

Integration Goal: *To incorporate the knowledge gained from resource management experiences, and information needs of management and planning into the design and implementation of our ecological monitoring.*

- 1) Are Management Concerns Likely to be Conducive to a Science Solution?

Improving management decisions through scientific knowledge is one of primary goals of the Natural Resource Challenge. However, we must recognize that some decisions are limited more by social values than by a lack of science. Lee (1993) proposed that management can be thought of as a vessel by which we influence natural systems, and that navigation of this vessel can, and should be, also influenced by sociological and economical forces. Policy, as a guide to management, helps to determine our final destination; whereas, science, can help to determine the route by which we reach that destination. When a decision is impeded by uncertainty about the outcome of management action, then science is more likely to be an effective means by which management decisions are improved. However, if a decision is impeded by disagreement about the priorities or direction of our management goals, then science may not be the most effective tool to resolve the conflict. In this case social and economic considerations may play a more important role, where negotiation and compromise of our goals is more likely to produce resolution to decision conflicts.

- 2) Assessment of information needs (for management)

Scientists have been criticized, and perhaps rightly so, for producing science products (e.g., models, reports, scientific papers, etc) for which they expound in great detail on their potential utility for management, but at the same time failing to make products that are very useful to management. One reason for this disparity is that seldom do scientists and managers come to consensus on a common goal. It is unlikely, or even desirable, that we should turn scientists into managers and managers into scientists, but we should recognize that scientists and managers have a common interest in being able to predict the behavior (responses) of the ecosystems that are being managed. Thus, coming to a common understanding about where and how this com-



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mon interest can be useful to management would be of great benefit. Thus, we should strive to develop a process for determining what information is needed to inform management, and this should be done in conjunction with the development of communication tools to assure that the right information is communicated in the right form, to the right people, at the right time.

- a. Conceptual Models
- b. Integrating national park's planning and reporting cycles into science planning.

3) Writing objectives that facilitate improvement of management through science

A fundamental goal of the Natural Resource Challenge is to improve management of our parks through scientific knowledge, and how management objectives are formulated greatly influences our ability to achieve this goal. However, we need to recognize from the outset that science within the National Park Service is intended to advance our general knowledge about the dynamics and functioning of ecosystems that we manage (often considered basic science), as well as science intended to inform management decisions (often considered applied science). When the latter is being planned, management objectives form the basis of reference for the relative advantage of one management alternative vs another. How well a given objective serves as that reference will depend on how it is formulated. In particular, the clarity to which science can inform management decisions will be greatly influenced by attributes of management objectives such as its degree of specificity, its measurability, and whether it is expressed as a resource state (condition) or as an action.

4) Incorporation of management objectives/concerns into sampling design

The sampling design ensures that data collected are representative of the target population or area, thus determine how samples are taken over time and space. If monitoring is intended or expected to inform management, then this needs to be taken into account in the sampling design in order to be effective and reliable. Some of the considerations should be: (1) Are alternative management actions potentially being planned such that they could be considered as treatments within the sampling design? (2) Are there sub-



sets of the resource or area being sampled that have been managed differently or that represent different ecosystem conditions that would influence management; and therefore would require or benefit from monitoring results that are assessed specifically for each subset? (3) Similarly, are there subsets of the resource or area that do not need to be assessed separately, but should explicitly be included in the sample in order to represent the range of variability likely to be encountered during management?

III. Incorporating Monitoring Results into Management

Integration Goal: *To incorporate the knowledge gained through science, including research and monitoring, into park resource planning, management, and decision processes.*

- 1) Incorporating real-world uncertainty (around science) into management and planning... Managers make decisions without information.
- 2) Linking science to management planning processes
- 3) Ecological Thresholds

Ecological thresholds are points at which an abrupt change occurs in the condition or functioning of an ecosystem. This concept emerged from the idea that ecosystems often exhibit multiple “stable” states (Lewontin 1969, Beisner et

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al. 2003, Groffman et al. 2006). The analog to ecological thresholds in the physical sciences dates back to the 1700s, when John Dalton described the changing state of water from a liquid to vapor (Huggett 2005). Certainly not all ecosystems exhibit threshold responses to ecosystem drivers or stressors, but such responses have been frequently found in studies of aquatic systems, wildlife responses to landscape change (e.g., fragmentation and habitat area), wildlife population dynamics, and community responses to invasive species. It is important to consider the possibility of threshold responses in management because the costs and consequences of crossing them may be quite high. Once a threshold is crossed, it may irreversibly shift an ecosystem to an undesirable state, limit the future management options, or force policy choices (Groffman et al. 2006). However, predicting and preventing threshold responses can be quite challenging due to the inherent complexities that may trigger them and the interactions that result from them.

4) Adaptive Management

Adaptive management has been interpreted in a variety of ways by resource managers since its initial conception by Holling (1978), Walters (1986), and others. The British Columbia Ministry of Forests has proposed, what is perhaps one of the more succinct definitions, of: “a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs”. Adaptive management is an interactive process that includes defining management objectives, assessing the existing conditions, developing and implementing management alternatives, monitoring and evaluating the results, and incorporating what is learned into future management decisions. Implicit in virtually all interpretations of adaptive management is the notion of explicitly incorporating learning into management for the purpose of making better resource management decisions. This concept has obvious intuitive appeal, which perhaps explains why its namesake



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has received such wide recognition. This approach is also being embraced as part of the National Park Service General Management Planning (NPS 2005).

5) Develop and use of decision support to inform management

a) Decision support systems

6) Cumulative “Evidence-based” Approaches

a. The Cochrane Collaboration

The Cochrane Collaboration is an international, non-profit, organization, established to ensure that up-to-date, accurate information about the effectiveness of medical practices is readily available worldwide. Its origin is traced back to a publication by Archie Cochrane (Cochrane 1972), which highlighted the tendency for medical decisions to reflect anecdotal information rather than cumulative evidence of the effectiveness of a given practice. The group now has centers throughout the world, which are dedicated to conducting systematic reviews of the scientific evidence for medical practices, and maintaining a database to distribute that information. Its relevance to resource management is that it is the analog from the medical field, and the model from which evidence-based conservation emerged.

b. Evidence-Based Conservation

Evidence-based Conservation is an approach that has been recently emerging, largely from Europe, to improve resource management decisions. Evidence-based conservation is based on an analogous approach in the medical sciences called the Cochrane Collaboration (see below). The premise behind these approaches is that decisions, whether they be in the medical or conservation fields, are often based on anecdotal evidence (Sutherland et al. 2004), which is seldom scrutinized as to their long-term effectiveness. Thus, the intent of evidence-based conservation is to conduct systematic appraisals of the evidence used to make resource management decisions and making those appraisals readily available to managers for future decisions (Pullin and Knight 2001). The approach is clearly related to the concept of adaptive management, but practitioners of this approach suggest that evidence-based conservation

has an added value of providing information from which to base an initial assessment; thus reducing the need to learn by mistakes (Pullin and Knight 2003). Thus, the ideas of evidence-based conservation may be well suited to use in concert with adaptive management.

c. Bayesian Inference

It is seldom, if ever, the case that there is one piece of science that provides a definitive answer to a particular resource management issue. It is far more likely that we would want to weigh the cumulative evidence to understand the consequences of a given resource management decision. Bayesian statistics is a quantitative tool that, by its very nature, enables incorporating previous evidence and knowledge, along with newly acquired data, to estimate the probability of a particular outcome. Although the mathematics are beyond these introductory comments, Bayes' Theorem essentially works to produce the probability distribution of an outcome, using (1) the cumulative existing knowledge, described in the form of a prior probability distribution, (2) the likelihood of existing data, given the prior probability distribution, and (3) a constant.

d. Meta Analyses

Meta-analysis is a statistical approach designed to accumulate scientific results across independent studies that address a related set of questions. In contrast to traditional analyses, meta-analysis uses the summary statistics from individual studies as the data points. A major advantage of this approach is that it uses the cumulative evidence from multiple studies to derive conclusions. However, if the studies being synthesized are from outside the population





or area of interest, meta-analysis can introduce additional heterogeneity to the results that may or may not reflect local conditions. Additionally, studies that are included in the meta-analysis that were improperly designed can result in spurious conclusions, prompting some investigators to advocate that inclusion of studies be limited to those of sound design.

7) Diffusion of Innovations Theory as a means of understanding how scientific knowledge and technology are adopted by land managers.

New ideas and approaches (innovations) are constantly being developed, and whether or not they are effectively incorporated into management depends on a number of factors that have been outlined within a theoretical framework known as diffusion of innovations theory. The theory contends that the process of adoption by a given manager involves a sequence of stages, which affect a manager's willingness and ability to adopt an innovation. These stages include awareness of the innovation, interest in the innovation, understanding the innovation, evaluation of the innovation, and finally a decision to adopt the innovation. The rate, and/or likelihood of widespread adoption would further depend on the qualities of the innovation, particularly: (1) the relative advantage of the innovation over alternative ideas, (2) the compatibility of the innovation with existing values and/or frameworks, (3) the simplicity or ease of use of the innovation, (4) the ease with which the innovation can be tested in a limited capacity, and (5) the observability of effective results when applied.

8) Develop enterprise information systems that give managers better access to science and monitoring information and knowledge

IV. Roles and Responsibilities

[Under Construction]

Integration Goal: To identify, understand and clarify the roles and responsibilities of various internal and external stakeholders in the integration of science and resource management.

- 1) I&M Networks
- 2) Park Managers
- 3) Internal Programs and Partners
 - a) RLCs
 - b) CESUs
- 4) External Partners

Implementation

V. Bringing it altogether