

# Information Management: Barrier or Bridge to Integrating Natural Resources Science and Management?

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## Introduction

OVER THE LAST CENTURY, federal land-management and regulatory agencies have amassed tremendous amounts of natural resources data. Next to the vast natural resources on public lands, information is perhaps the greatest public asset managed by these agencies. The potential value of these data to managers and scientists is well appreciated, but not always well received. That is, we are often aware of the information and anticipate its value and utility to addressing a particular management, monitoring, or research need, only to encounter unanticipated barriers related to how the information may have been collected, documented, or managed. Historically, agencies have committed funds and effort to data collection that far surpassed those allocated to data management. However, over the past decade, agencies have been changing this practice and now obligate significant resources to information management. Agencies are behaving more like corporations by applying business-driven, or “enterprise,” concepts and principles to information management. Enterprise solutions are those that facilitate the communication and exchange of information throughout an entire organization, including among functions, divisions, or other components. The concepts are applied through information technologies and architectures (hardware, software, and data models that are typically structured in a top-down hierarchy), that enhance an agency’s ability to share information, integrate systems, reduce costs, increase productivity, and improve data quality. At the federal departmental level (e.g., Interior, Agriculture, and Commerce), commitments to supporting enterprise information architectures have been substantial.<sup>1</sup> Nevertheless, challenges and frustrations continue to hinder efforts to share data across projects, programs, and agencies.

In this essay, I will describe a range of information-management barriers that continue to obstruct basic efforts to integrate science-based information with natural resource monitoring, planning, and management. I will also propose some solutions to those barriers. Some of the barriers can be bridged with minimal time and effort by applying appropriate technology and fund-

ing; others may be too costly to bridge. The existing information-management infrastructures and systems unique to each agency—and often among programs within agencies—present significant challenges to information sharing, but can be resolved. Other barriers are deeply ingrained in human attitudes and agency cultures and may take as many decades to change as it

took to amass the vast amounts of data at hand. The natural resource data collected through research, monitoring, management, and planning should be available across disciplines, programs, and agencies for analysis, synthesis, and application to management challenges.

## **Background**

The basis for my observations comes largely from my experience working with long-term natural resources monitoring programs, particularly the Interagency Effectiveness Monitoring Program for the U.S. Forest Service's and Bureau of Land Management's Northwest Forest Plan. This was a comprehensive, broad-scale, 100-year land resource management plan, with the long-term goal of sustaining resources related to mature and old-growth forests, as well as resource-reliant economies within the range of the northern spotted owl. The agencies cooperating on the plan recognized the need for an effectiveness-monitoring strategy, and targeted the first analysis of the overall effectiveness of the Northwest Forest Plan for 2004, 10 years after the plan was implemented. The results presented in the 10-year interpretive report would be used to adaptively adjust management strategies and make adjustments to the monitoring program.

## **Requirements analysis**

Long-term monitoring and analysis relies on a wide range of internal (collected directly by the monitoring program) and external (collected by other programs) data and information sources. When I joined the effectiveness-monitoring program in 2001, I initiated a requirements analysis to identify internal and external existing data and new information needed for the 10-year

interpretive report. Generally, the process focuses on analyzing the strategic business and functional information needs of a program. The result should be a clear understanding of the required data, data models, analysis applications, software, hardware, connectivity, and standard operating procedures for information management.

Because of time and resource constraints, the effort focused on documenting the functional needs of the monitoring program in the context of the 10-year interpretive report. The analysis included documenting the monitoring objectives and questions; identifying required data attributes, including scale and resolution; describing the summarization or analysis of the data; and discovering existing data sources. The specific steps followed were:

- **Document the questions that need to be answered.** What are the monitoring questions related to each indicator? What other questions will be addressed by the monitoring program (e.g., questions centering around implementation, resource outputs, and expectations)?
- **Identify attribute-specific information or data needs.** What types of data are needed to answer the monitoring questions? What are the required attributes of the data?
- **Determine the scope, scale, and resolution requirements of the analysis.** What are the required temporal and spatial scales of the analyses? What are the required temporal and spatial resolutions of the data?
- **Understand the data-processing needs.** What new data models are required? What analysis applications are required?

- **Estimate the effort required to acquire existing candidate data.** Where is the information located? Can the required information be obtained?

Throughout the process, I tracked issues that emerged at each step and documented them in a data-issues log. For each potential data source, this documentation included a statement of the issues, the affected operations, potential impacts on completing the 10-year interpretive report, and recommendations for addressing the issues. Once documented, the issue statement was assigned a number and logged for tracking and resolution.

### **Categories of barriers**

By February 2003, the requirements analysis had identified 110 data sources needed by the monitoring program. Fifty-four of these datasets were determined to be critical to producing the 10-year interpretive report. Analysis of the information recorded in the issue-tracking log revealed several categories of issues that presented significant barriers to integrating datasets and other information critical to evaluating the effectiveness of the Northwest Forest Plan:

- **Existence.** The data were believed to exist but could not be located, or were so incomplete that for all practical purposes, they were nonexistent. Collecting or producing new data was considered cost-prohibitive or impractical because of limited resources and reporting deadlines.
- **Access.** Data existed and could be located, but could not be acquired in a timely manner (with regard to a specific need). No stewards or point of contacts were available, or funding limitations prevented programs from responding to major data requests from external users.
- **Consistency.** Data were distributed among multiple sources, such as various agencies, districts within an agency, or cooperators, and were inconsistent across sources. Even when data were well documented, their utility was severely limited because of inconsistencies in many characteristics, such as data definitions, standards, quality, extent of documentation, and maintenance.
- **Compilation.** Data may have been accessible, documented, and even consistent across sources, but substantial resources were needed to compile the information to the necessary scale.
- **Maintenance.** Data had not been managed or stewarded over time and required updating or migrating to current standards. Resources were committed to data collection, but no commitment was made to the maintenance of the information.<sup>2</sup>
- **Documentation.** Metadata (information about the data) were missing or incomplete. Even when metadata existed, they were so incomplete or inadequate that evaluating the qualities and utility of the data was unachievable.<sup>3</sup>

### **Impacts of barriers**

The most common barriers to integrating existing data into the effectiveness-monitoring program were consistency, compilation, and maintenance. Often, data were available to address monitoring questions, but other barriers—existence, access and documentation—were encountered in

attempts to collate this information into regional datasets.

The lack of consistency among similar kinds of data from various agencies and programs was a primary barrier. Examples included differences in how intermittent streams were mapped and how data on roads and other infrastructures were collected. Another example was the difference in approaches taken to vegetation modeling and mapping across administrative boundaries.

Compilation was another barrier of major importance. It was difficult to develop a regional data layer of riparian corridors and to compile spatial data on ground-disturbing activities across the area managed under the Northwest Forest Plan. Agencies and programs may have tracked projects such as timber sales, mining activities, or restoration projects, but without common standards for data attributes or spatial referencing, compiling the information to the scale necessary for analysis was impossible in many cases.

The lack of maintenance or upkeep of regional datasets was also a significant barrier. Obtaining a regional-scale land use allocation or management zone data layer required substantial effort. Original layers from when the Northwest Forest Plan was implemented—in 1994—had not been updated to reflect changes over the years for attributes such as boundary adjustments or land use zoning. In several cases, the existence of required data was anticipated, but found to be non-existent or incomplete for the area managed under the Northwest Forest Plan. Examples included a lack of digital orthographic photo-quad coverage and a lack of data for determining the cost associated with planning requirements on the whole.

Several issues emerged as secondary or contributing barriers; that is, a primary barrier was encountered, and then further compounded by other issues. Incomplete data were often significant contributing barriers to many information needs, including the identification of riparian corridors and streams. The inability to access data was a significant contributing barrier as well, including basic data on the location of ground-disturbing activities and recreational uses. Missing and inadequate documentation, or metadata, was a very significant contributing barrier to integrating numerous data sources for several needs.

### **Bridging the barriers**

The barriers to integrating existing data into long-term natural resources monitoring and management are more complicated when multiple agencies or programs are involved. In most cases, the solutions are not simple—but neither are they insurmountable. Generally, land-management agencies are at varying stages of maturity with their respective information-management strategies and architectures, and, with few exceptions, interagency coordination on information management is limited—in the past, even avoided. The tendency of agencies, even within a single U.S. government department, to apply different technologies, software, hardware, and intranets (with firewalls), and have differing information-management organizations, produces information environments and “cultures” that present barriers not only to information sharing, but also to basic communication. Cooperating agencies and programs need to provide people with the appropriate authority to overcome information-management issues and barriers to integration. Support staffs with an understanding of

natural resources business needs, information technology, agency-specific information environments, and data stewardship, collection, and production are required. Key elements of a proactive strategy to facilitate interagency cooperation on meeting the information needs of broad-scale, long-term monitoring programs include:

- **Adoption of an enterprise approach to data management.** Encourage collaborative actions among agencies and programs collecting and managing essential data. Define the enterprise to include all programs or efforts potentially contributing essential information. Engage these programs in collaborative analysis of requirements so that partner and client needs can be identified and taken into account as data are collected and shared. Support information technologies that are not tied to one agency's or program's information architecture. *Key to bridging all barriers described above.*
- **Executive/management oversight.** Provide directors or other managers with the authority to approve information needs and projects, commit resources, and require accountability. *Key to bridging all barriers described above.*
- **Interagency/interprogram standardization.** Define and document required information standards, metadata, and stewardship needs. Include defining enterprise software and hardware requirements for interagency data structures and information processes. Ensure that the group has knowledge of existing agency information environments, information technology regulations, and cultures. *Key to bridging bar-*

*riers related to data consistency, maintenance, and documentation.*

#### **Interagency/interprogram stewardship.**

Support staff positions with knowledge of programs (e.g., monitoring, planning, compliance) and their business needs; those positions require skills to articulate information content, standards, and maintenance requirements, and the ability to work with production staff in developing work plans and budgets. *Key to bridging barriers related to data, compilation, maintenance, and documentation.*

#### **Implementing solutions**

By design, land-management agencies are a combination of “top-down” and “bottom-up” organizations relative to decision-making about natural resources. Guidance on process is provided at the departmental and agency levels, but strategies and actions are often delegated to, and developed and implemented at, the local level. Since the establishment of most federal land-management agencies, natural resources data-collection protocols and information-management practices have been typically addressed at the level of the local administrative unit—national forest, district, or national park—or at program levels. The result has been the long-term development of deeply ingrained cultures of distributed decision-making authority and local ownership, which has contributed to the barriers to integrating natural resources science and management. Clearly, applying enterprise concepts and solutions within the existing information-management architectures and cultures of federal land-management agencies is a challenge and will take time.

As was pointed out in the introduction, however, federal land-management agencies

are making headway, due to demand and support at the field and departmental levels. The U.S. Forest Service, for example, is in the midst of a long-term effort to implement the Natural Resources Information System (NRIS). The NRIS combines standard corporate databases and computer applications to support field-level users. The data models are managed nationally, but the applications are installed and managed in a distributed manner, typically at the regional and forest levels. The transition from local to enterprise solutions has been as much a cultural as a technological change for the Forest Service, and investments have been large—approximately \$10 million per year during the first few years of NRIS development.

Within the National Park Service, another significant effort is underway to define business-driven requirements for managing natural resources information: Protecting Resources through Informed Decisions and Education, or PRIDE. PRIDE is following the Department of Interior's Methodology for Business Transformation (MBT) process, which is expected to generate a servicewide blueprint for enterprise information architecture that will include natural resources inventory, monitoring, and research data. The Park Service has also implemented programs that are generating changes in the agency's culture with regard to natural resources science and

monitoring information. The Inventory and Monitoring program groups over 270 parks into 32 networks. In the past, parks were relatively independent entities, and often had to compete for the same financial resources. With the network approach, network parks share resources for monitoring natural resources conditions and trends. The program has a policy of committing one-third of its resources to data management and reporting. Numerous other federal agencies are also implementing solutions to natural resources information-management barriers, including the Bureau of Land Management and Environmental Protection Agency.

Replacing information-management barriers with bridges is critical to integrating natural resources science, planning, and management. The success of many natural resources planning and monitoring efforts, such as the Interagency Northwest Forest Plan and National Park Service Inventory and Monitoring program, depends on enterprise-type solutions that promote reasonable levels of standardization and information stewardship to ensure that data are usable. The solutions must address issues related to data access, consistency, compilation, maintenance, and documentation across agencies, programs, and partners that expect to share information for the purpose of managing the vast natural treasures on public lands.

## **Endnotes**

1. These agencies have all adopted the same definition for "enterprise architecture": A strategic information asset base that defines the business, the information necessary to operate the business, the technologies necessary to support the business operations, and the transitional processes necessary for implementing new technologies in response to changing business needs. It is a representation, or blueprint.
2. Because of the substantial costs of maintaining data, such as inventories and other sources of land-management information often used in planning, data sometimes suffer

from neglect. In the short term, recollecting data according to the planning cycle can seem more cost-effective than using existing data. However, this strategy ignores long-term needs for maximum use of existing data to maintain historical baselines.

3. Creating or recreating the documentation years after the data had been produced is often impossible because of attrition in institutional knowledge.

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