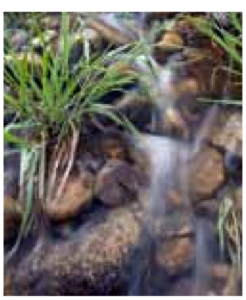
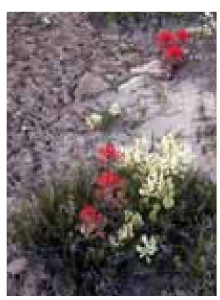
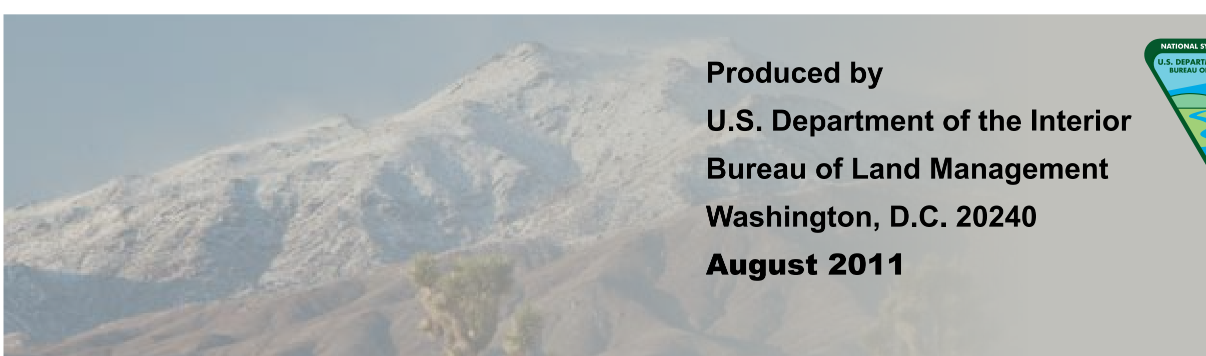
Bureau of Land Management

Assessment, Inventory, and Monitoring Strategy

For Integrated Renewable Resources Management







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BLM

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Assessment, Inventory, and Monitoring Strategy

For Integrated Renewable Resources Management

Authors:

Gordon R. Toevs, AIM Coordinator,
BLM Washington Office, Washington, DC

Jason J. Taylor, Landscape Ecologist,
BLM National Operations Center, Denver, CO

Carol S. Spurrier, Rangeland Ecologist,
BLM Washington Office, Washington, DC

W. Craig MacKinnon, AIM Coordinator (retired),
BLM Washington Office, Washington, DC

Matthew R. Bobo, Remote Sensing Specialist,
BLM National Operations Center, Denver, CO

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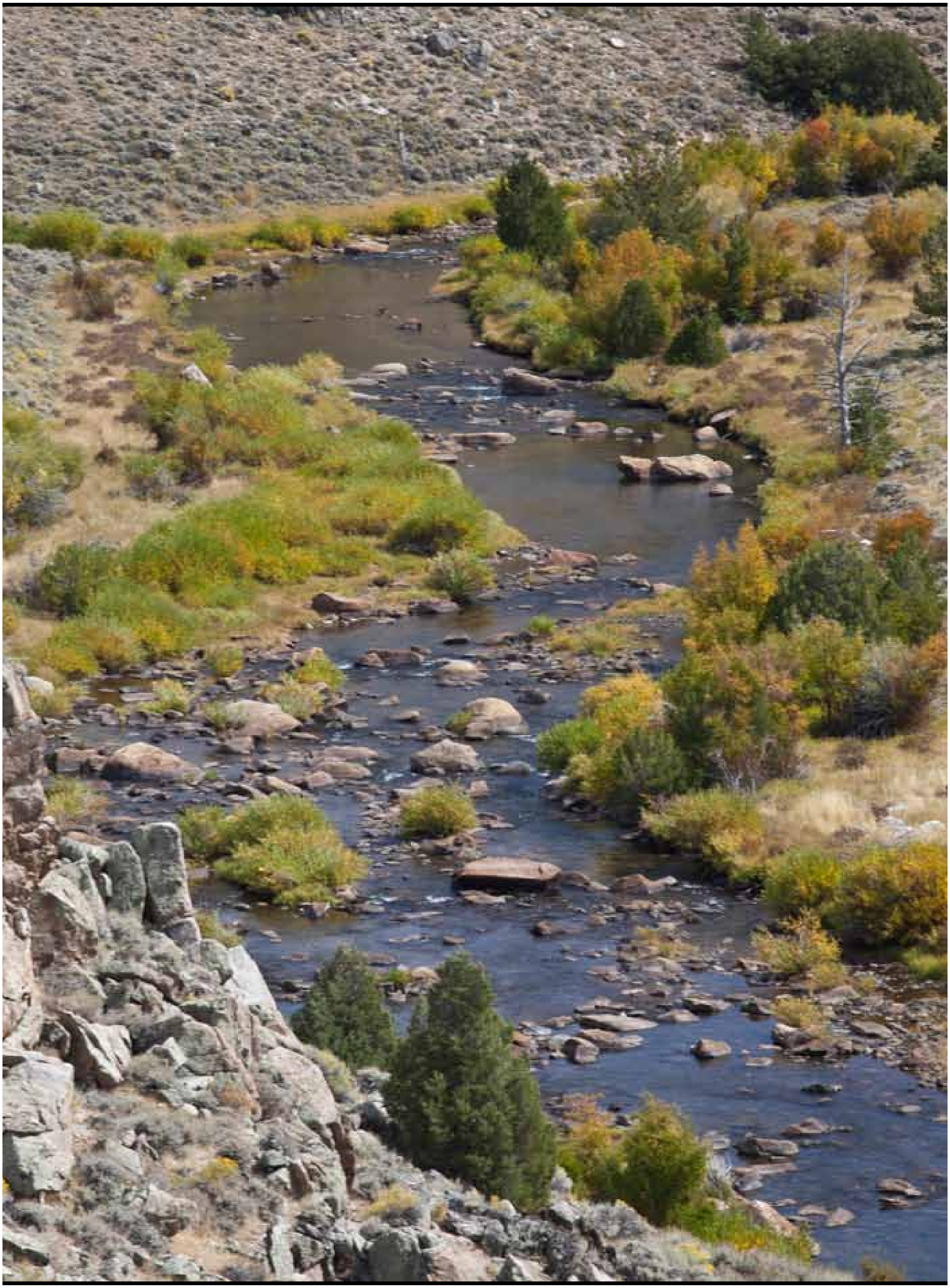

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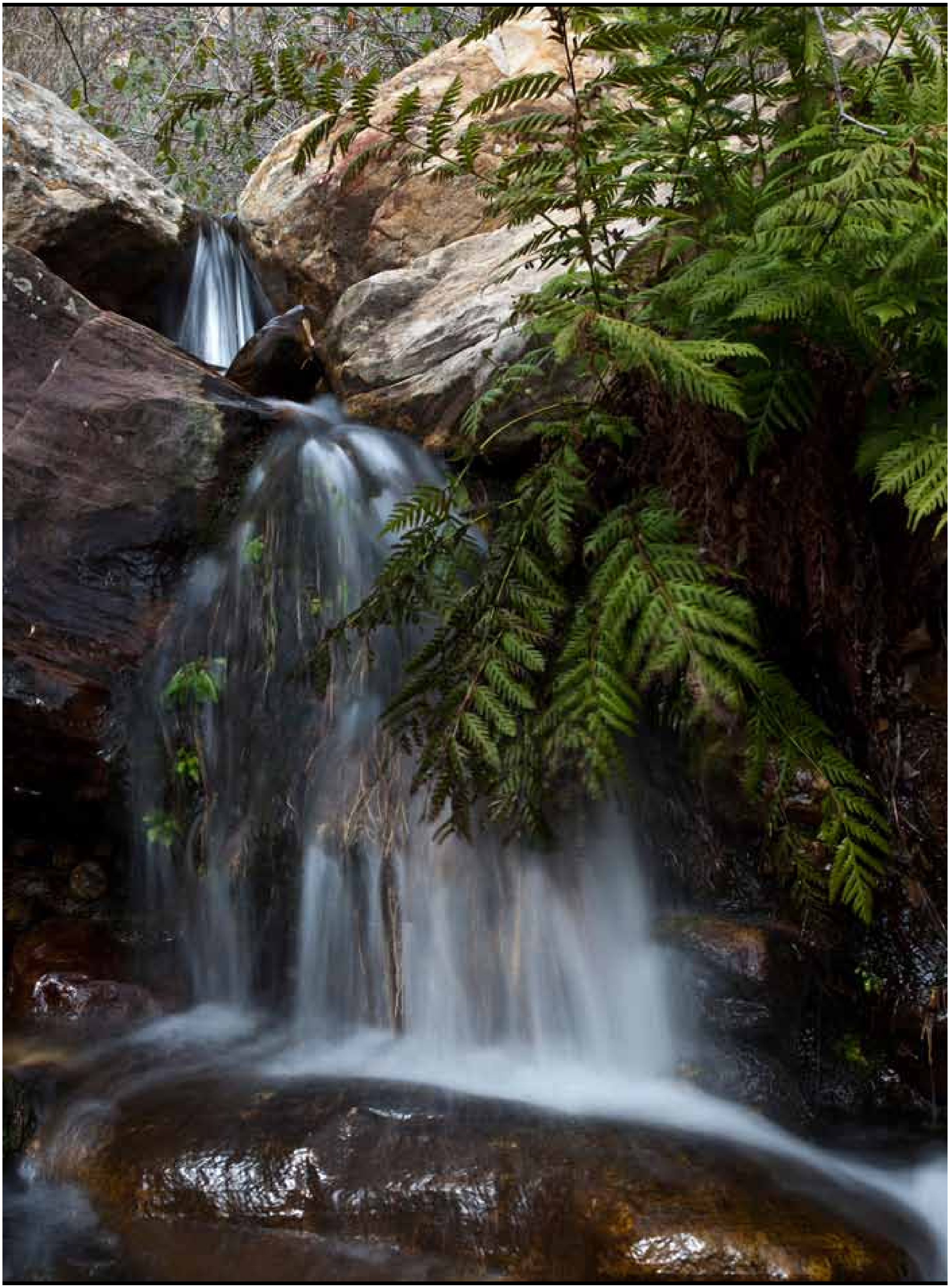
Executive Summary

In 2004, the Office of Management and Budget (OMB) conducted a program evaluation of the Bureau of Land Management (BLM) resource protection activities. The OMB found “gaps in the monitoring of resource conditions to support management decisions” and that the BLM had no reliable mechanism for reporting on the condition of public lands above the local scale. The BLM established an Interdisciplinary Core Team that evaluated assessment processes, resource inventories, and monitoring procedures and developed a comprehensive plan of action that would lay the foundation for a monitoring strategy. Two reports, (1) the Local Workgroup Report for the National Assessment, Inventory, and Monitoring Strategy (BLM 2007) and (2) the Findings and Recommendations for Regional Monitoring for Wildlife and Water with an Emphasis on Energy Development (Falise et al. 2008), were also completed and provided vision toward developing an Assessment, Inventory, and Monitoring (AIM) Strategy. Following these initial inputs, the BLM funded numerous pilot projects to test work processes that would move the Bureau toward integrated data collection, allow management of data as a corporate asset for multiple uses, and improve data accessibility for the field and Washington Office. The insight gained from the above activities guided this strategy document which will be followed with an implementation plan.

The AIM Strategy is intended to reach across programs, jurisdictions, stakeholders, and agencies to provide data and information valuable to decisionmakers. The strategy focuses on 10 management questions important to land managers at varying levels of the Bureau, from field office to national levels. Answering each of the management questions requires a multiscale, coordinated, and integrated approach for new data collection while recognizing the value of many current monitoring activities. This approach will provide: (1) an opportunity to collect monitoring data that can be used many times for many purposes and (2) the quantitative data essential for informed, defendable land management decisionmaking.

To effectively manage renewable resources, the BLM needs information at multiple scales about resource extent, condition and trend, stressors, and the location and nature of authorized uses, disturbances, and projects. Acquiring and assessing this information will be accomplished through the integration of several fundamental processes (i.e., the integrated approach), including the: (1) development and application of a consistent set of ecosystem indicators and methods for measuring them (i.e., core quantitative indicators and consistent methods for monitoring); (2) development and implementation of a statistically valid sampling framework; (3) application and integration of remote sensing technologies; and (4) implementation of related data acquisition and management plans (e.g., Geospatial Services Strategic Plan, Enterprise Geographical Information System architecture, and rapid ecoregional assessments).

The benefits of the AIM Strategy to the BLM will be achieved through the implementation of a suite of actions, which include updating policy and guidance documents; integrating monitoring activities, budgets, and performance measures across programs; and developing associated communication tools and training modules. These action items will be defined in an associated implementation plan. The AIM Strategy will move the BLM toward a new paradigm where core data describing resource condition are digitally collected in the field, stored in spatially enabled databases, managed in an enterprise data architecture environment, analyzed to determine effectiveness of management actions, and shared across BLM offices and interested publics.



Needs Statement

To effectively manage renewable resources, the BLM needs information at multiple scales about:

- Resource extent (location and abundance);
- Condition and trends (of plant species/vegetation communities, wildlife populations/habitats, soils, and watersheds);
- Stressors (existing and potential risks or change agents); and
- Location and nature of authorized uses, disturbances, and projects.

To determine the information needed for effective management of renewable resources, the BLM needs:

- To develop conceptual ecological models illustrating the key components (attributes) of ecosystem sustainability and the interaction of stressors (e.g., fire, development, invasive species, and climate change) on ecosystem capacity. These models will be used to identify important processes, facilitate communication, guide planning decisions, and provide a scientific framework for selecting indicators to monitor; and
- A process to understand and evaluate the cause-and-effect relationships of ecosystem stressors and ecosystem functions for cumulative effects analysis and to develop adaptive management strategies.

To use this information, the BLM needs:

- A systematic approach for integrating key components (attributes) into planning decisions, monitoring programs, and research needs.

The BLM needs resource information at multiple scales:

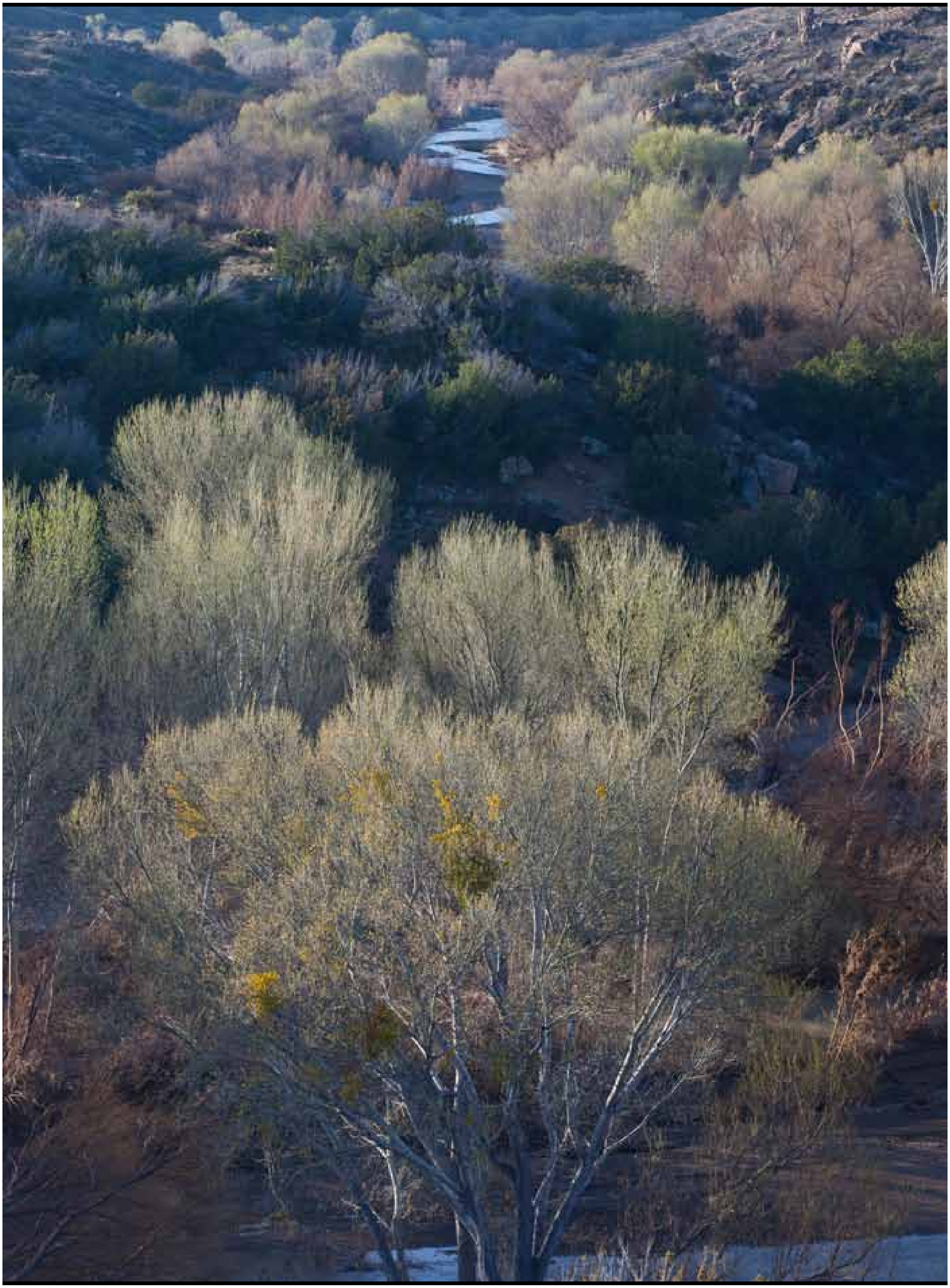
- At the **field office level** to develop land use plans and resource objectives, conduct land health evaluations (including land health assessments and riparian proper functioning condition), determine the effectiveness of management actions, analyze cumulative effects, make adaptive management decisions, and document use compliance;
- At the **regional level** to detect landscape-level change in resource extent and condition, analyze cumulative effects, develop regional mitigation strategies, report on landscape metrics (e.g., patch size and connectivity) including conservation targets and wildlife corridors, and improve regional datasets; and
- At the **national level** for periodic reporting on renewable resource distribution, abundance, and trend.

To acquire and manage resource information in the most effective and efficient manner, the BLM needs to:

- Make data collection and management a corporate priority;
- Integrate data acquisition and data management across programs and across jurisdictions to maximize the benefit of data collected;
- Adopt and implement core indicators, standard collection methods, data standards, and a defensible sampling framework for the collection of quantitative data;
- Integrate quantitative data with remote sensing as a fundamental process;
- Implement electronic, onsite field data capture technologies; and
- Digitize legacy data for inclusion in decisionmaking analyses.

To address the needs stated above and implement associated processes into the fabric of the BLM, the BLM needs to:

- Update and develop cross-program guidance;
- Determine appropriate output and outcome performance measures;
- Train renewable resource staff under an "integrated approach;" and
- Focus funds in priority areas (e.g., watersheds) for conservation and restoration.



Introduction

This AIM Strategy addresses renewable resource data collection specific to vegetation, associated habitats for wildlife, and the supporting ecological components of soil and water. In general, the strategy is intended to: (1) document the distribution and abundance of natural resources on public lands; (2) determine resource conditions; and (3) identify natural resource trend or change. These objectives will be accomplished through the integration of fundamental processes including the: (1) development and application of a consistent set of ecosystem indicators and methods for measuring them (i.e., quantitative core indicators and consistent methods for monitoring); (2) development and implementation of a statistically valid sampling framework; (3) application and integration of remote sensing technologies; and (4) implementation of related data acquisition and management plans (e.g., Geospatial Services Strategic Plan, Enterprise Geographical Information System architecture, and rapid ecoregional assessments). In addition, this strategy provides a path forward to systematically identify landscape-scale values and risks.

In combination, resource distribution, abundance, and trend describe a form of land health (i.e., condition). Traditionally and formally, the Bureau defines and measures land health through assessments and evaluations against predetermined conditions defined in 43 CFR 4180.1 Fundamentals of Rangeland Health and state-specific rangeland health standards developed in consultation with Resource Advisory Councils (e.g., see http://www.blm.gov/co/st/en/BLM_Programs/grazing/rm_stds_guidelines.html). These standards provide the minimum objectives for land use plans and resource-allocation decisions. However, the Bureau has limited staff and resources, making complete, distributed, and reoccurring assessments and evaluations difficult to accomplish. To help address this issue, the AIM Strategy introduces an approach that will:

- Prioritize where the BLM conducts traditional land health standard assessments;
- Prioritize areas for quantitative data collection following a statistically valid sampling design to meet multiple objectives;
- Utilize remote sensing technologies to detect change across broad landscapes; and
- Identify priority data for standardization and national geospatial dataset development.

This integrated approach provides a means for national-level reporting on resource condition, defensible data for informed land management decisions, and a mechanism for field office mangers to prioritize seasonal field work.

Background

OMB Evaluation

In 2004, the OMB conducted a program evaluation of the BLM's resource protection activities. The OMB found "gaps in the monitoring of resource conditions to support management decisions" and that the BLM had no reliable mechanism for reporting on the condition of public lands above the local scale. The OMB directed the BLM to analyze its monitoring activities and develop and implement a Bureauwide monitoring strategy.

Initial Steps

The BLM established an Interdisciplinary Core Team to collectively examine the assessment processes, resource inventories, and monitoring procedures and develop a comprehensive monitoring and assessment strategy. The team recognized that evaluating all BLM assessment, inventory, and monitoring activities at one time was too complex, so a decision was made to address the renewable resource activities first, and then proceed to other BLM programs like recreation, cultural, and other use-authorization programs. The team also recognized that the scale where assessment, inventory, and monitoring data are typically used must be addressed. The three scales identified were the national, regional, and local levels (i.e., field office).

To gain efficiency in data collection activities, the Interdisciplinary Core Team recognized that integrating assessment, inventory, and monitoring activities is vital. Furthermore, a set of common indicators would minimize redundancies in data collection and address multiple resource questions at multiple scales. The team also recognized the utility of using remote imagery to develop a seamless land cover map (including vegetation, disturbance, hydrology, etc.), monitor change, and document cumulative effects.

In 2007, a local workgroup report (BLM 2007) was completed; the report included a survey of 36 field offices and provided a vision toward developing this strategy. In 2008, a report was completed, titled Findings and Recommendations for Regional Monitoring for Wildlife and Water with an Emphasis on Energy Development (Falise et al. 2008). This report articulated the need for the BLM to move beyond office boundaries and state borders when assessing impacts to wildlife habitat, native plant communities, and water resources. Additionally, in 2008, the BLM Washington Office (WO-800, Business and Fiscal Resources) conducted an analysis of inventory and monitoring activities (BLM 2008b). Many field offices were visited to identify: (1) resource monitoring issues, (2) where efficiencies could be gained in monitoring programs, and (3) where monitoring best management practices were in effect.

The BLM funded numerous pilot projects to move the Bureau toward integrated data collection and management of data as a corporate asset for multiple uses. Pilot projects were designed to improve resource data management and preserve legacy data at multiple scales. These projects have varied substantially in scale, from monitoring site-specific projects, to testing national sampling strategies covering more than 30 million acres in central Oregon, and to exploring remote sensing technologies for vegetation condition and trend. Examples of the pilot projects include:

> **Land Treatment Digital Library (LTDL)** - The LTDL, developed by the U.S. Geological Survey (USGS), contains legacy data on land treatments and projects (e.g., seeding mixtures, treatments applications, reports, plans, monitoring data, photographs) that can be analyzed with existing soil/ecological site data, historical weather, and other resource data sources. This information is easily accessible by BLM personnel. These data can be used by regional and local managers for project-level activity planning, fire management activities, resource management plan (RMP) development, ecoregional assessments, and other emerging issues.
>
> **Terrestrial Core Indicators and Methods** - A set of core indicators and methods to capture key ecosystem attributes was developed that applies to rangeland, forest, and riparian ecosystems. Development of the core indicators and methods was an interagency effort, including the Agricultural Research Service (ARS), USGS, and resource specialists from BLM state and field offices, the National Operations Center, and the

Washington Office. The core indicators, quantified through standardized measurement methods, allow data to be integrated across field office, district, and state boundaries. The core indicators selected are comparable with a subset of those used for the U.S. Forest Service's (USFS) Forest Inventory and Analysis (FIA) program and the Natural Resources Conservation Service's (NRCS) National Resources Inventory (NRI) program.

Remotely Sensed Vegetation Mapping and Monitoring - The BLM partnered with the USGS to apply a new USGS technology for developing local- and regional-scale models of vegetation cover, in conjunction with the Billings RMP. The pilot project served as a proof-of-concept for several critical steps in moving the AIM Strategy forward, including: continuous vegetation mapping, multiscale landscape monitoring, and Westwide grass and shrubland mapping. Field methods used in the pilot will be adapted to ensure compatibility with data collected using standard methods and allow accuracy and precision to be reliably reported.

These and other pilot projects have indicated the Bureau has the ability and technical capacity to integrate data collection and management. Informed resource decisionmaking should be driven by a thorough understanding of ecological functions, which can be described using conceptual ecosystem models.

Ecological Models

The BLM is developing a landscape approach that highlights the need to reach across programs, jurisdictions, stakeholders, and agencies to manage for ecosystem sustainability (i.e., capacity), multiple-use mandates, and regulations found in the Fundamentals of Rangeland Health. One way to achieve this goal is to develop management questions, attributes, and indicators based on key ecological functions demonstrated within common, accepted conceptual ecological models.

Conceptual ecological models are used to summarize existing knowledge and hypotheses concerning the structure and functioning of ecosystems.

> An important goal of the [conceptual ecological] models is to depict how natural drivers (for example, climate) and anthropogenic stressors affect ecosystem structure and functioning. The ability of the monitoring program to detect the ecological effects of anthropogenic stressors is dependent upon interpreting trends in resource condition against the backdrop of natural ecosystem variation. Hypotheses concerning the effects of anthropogenic stressors on ecosystem structure and function must be grounded in an understanding of the relationship between natural drivers and the structure, functioning, and dynamics of ecosystems. Ecosystems can be characterized on the basis of far more structural and functional attributes than can be monitored affordably. Thus another important goal of the models is to guide the identification of a few important attributes that provide information about multiple aspects of ecosystem status (Miller 2005).

Conceptual ecological models, based on science and other expert input, provide a common language that addresses ecosystem sustainability, a means to identify indicators of key ecosystem attributes, and a basis for resource decisions predicated on maintaining or restoring ecosystem capacities. Further support for an ecological model approach is offered by the OMB, the Council on Environmental Quality (CEQ), and the Department of the Interior, which have directed science and land management agencies to work across jurisdictions in addressing environmental issues such as climate change. These efforts will be difficult to coordinate without a common understanding of ecosystem processes and dynamics described by a conceptual ecological model.

Three key ecosystem attributes of sustainable terrestrial systems provide a conceptual basis for how the BLM will describe, interpret, and monitor ecosystems for all resource programs at multiple scales. The three attributes are:

1. **Soil/Site Stability:** The capacity of an area to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water.

2. **Hydrologic Function (Water Cycle):** The capacity of an area to capture, store, and safely release water from rainfall, run-off, and snowmelt; to resist a reduction in this capacity; and to recover this capacity when a reduction does occur.

3. **Biotic Integrity:** The capacity of the biotic community to support ecosystem processes within the normal range of variability, to resist a loss in the capacity to support these processes, and to recover this capacity when losses do occur. The biotic community includes plants, animals, and microorganisms occurring in terrestrial and aquatic environments.

These three attributes are further described in Interpreting Indicators of Rangeland Health (Pellant et al. 2005). The importance of these key attributes can be observed within conceptual ecological models (see Figures 1 and 2). Unique models are established for each ecological site (i.e., groupings of similar soils and climates that support similar types and amounts of vegetation) to ensure that assessment and management are tailored to match the potential and ecological processes on each type of land.

Reinforcing the use of the three key ecological attributes (soil/site stability, hydrologic function, and biotic integrity) among the BLM's resource programs will provide an ecological template for integrating data collection and answering management questions at multiple scales within all levels of the Bureau and with

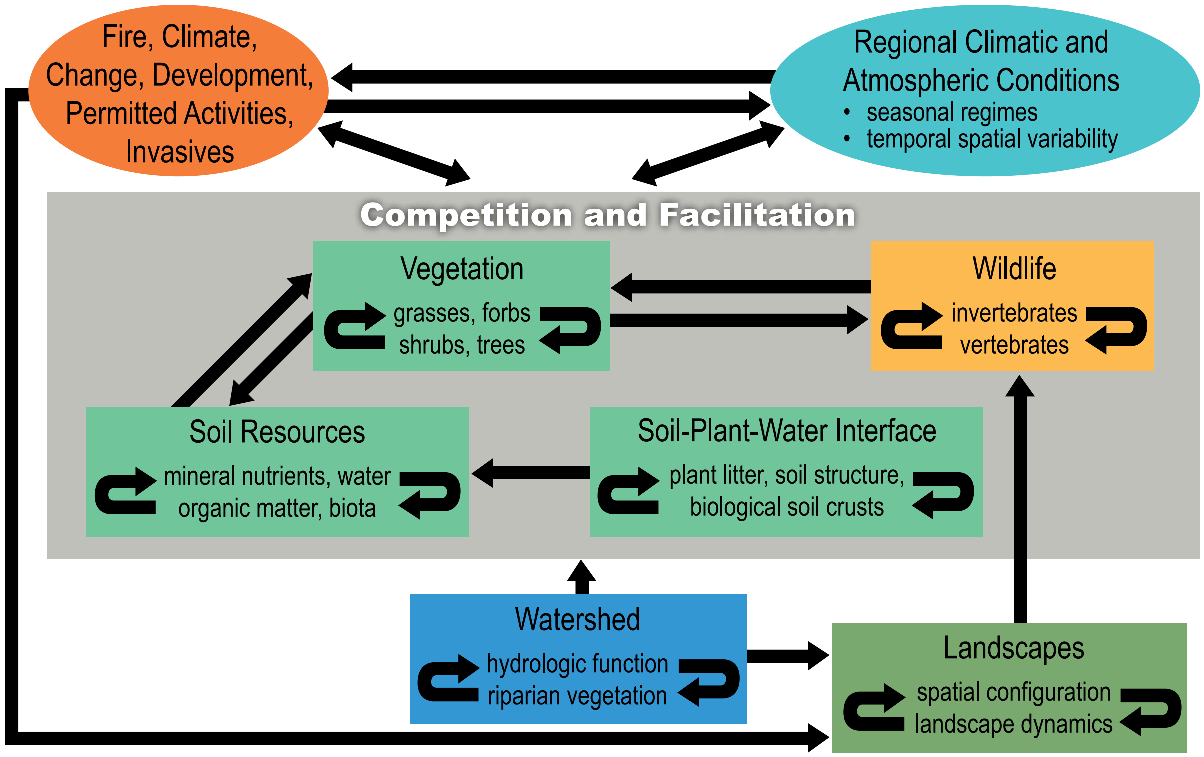


Figure 1. Conceptual ecosystem model derived from Miller (2005) depicting stressors/change agents (ovals) and functional ecosystem components (rectangles).

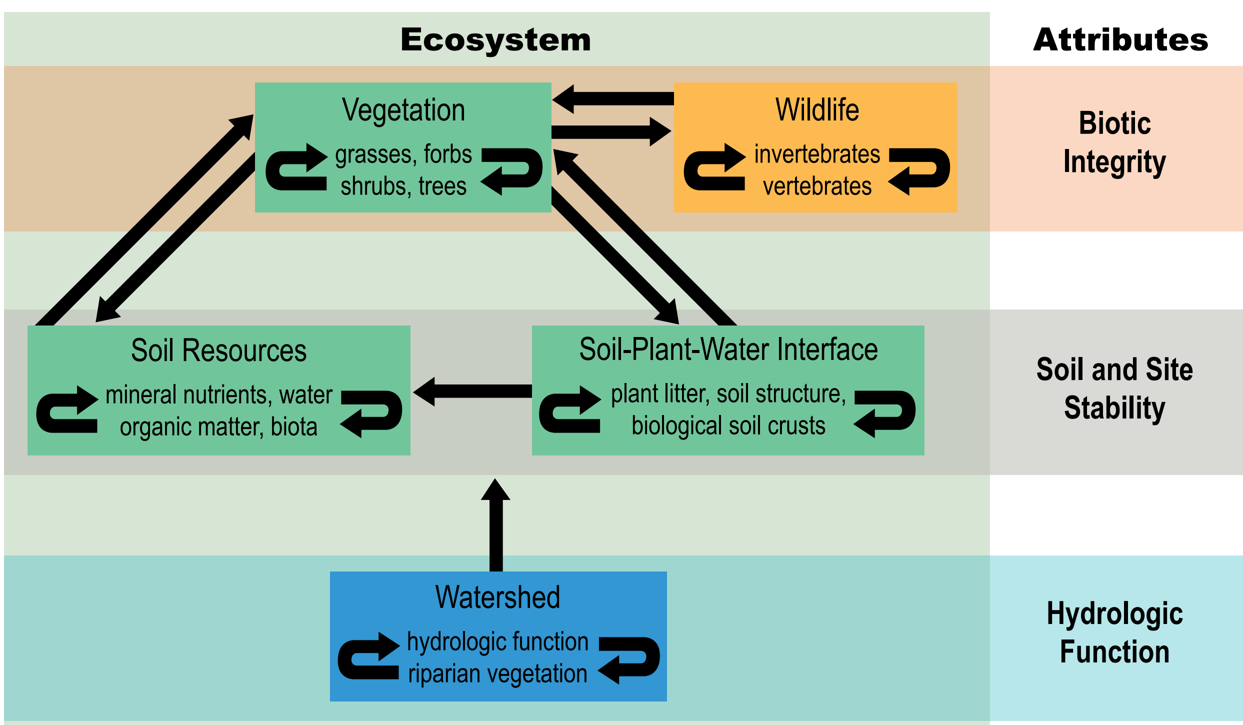


Figure 2. A model of reduced complexity showing essential renewable resources (structural components). Assessing and monitoring natural systems requires consideration of the major structural components of ecosystems (boxes) and their functional relationships (solid arrows). Key ecosystem attributes can be drawn from these components, with the recognition they are all interdependent.

federal partners. These three attributes give a broad context to the Bureau's role in managing for sustainability. That is, managing for "a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and non-renewable resources" to achieve sustained yield, which "means the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the public lands consistent with multiple use" (BLM and Office of the Solicitor 2001).

The AIM Strategy is driven by management questions at field, regional, and national scales. The following section describes these significant management questions.

Significant Management Questions by Scale

Management questions drive day-to-day activities within the BLM. The AIM Strategy intends to provide data and information valuable to decisionmakers and other interested publics. In order to accomplish this objective, the strategy will focus on management questions determined to be important to land managers at varying levels of the Bureau, from a field office to national levels. The management questions, and scale at which they typically occur, are:

Field Office Level

1) What ecosystem processes and sustainability concepts should be incorporated in land use plan development and decisionmaking?

BLM land use planning decisions should be based on maintaining functional capacities of ecosystems. Ecological models based on the three key ecosystem attributes (biotic integrity, hydrologic function, and soil/site stability) help describe the capacity of an ecosystem. Basing land use decisions on a conceptual understanding of how resource-use decisions affect ecosystem processes, and consequently ecosystem capacity, will help achieve sustained yield for future generations.

Evaluating the effects of land use decisions on ecosystem attributes and processes will support:

- Determination of sustainability of existing and proposed use allocations and authorizations;
- Understanding impacts of existing and emerging risks across broader landscapes;
- Adaptive management strategies; and
- Consistent descriptions of ecosystem capacities with other science and land management agencies (i.e., ARS, USFS, NRCS, USGS).

The local workgroup report (BLM 2007) recommended ecosystem modeling to promote a common understanding for ecosystem sustainability and to understand cause-and-effect relationships. This approach also addresses the OMB and CEQ need for a common description across land management agencies.

The AIM Strategy

To address this question, the AIM Strategy supports:

- Development of guidance to integrate key ecological attributes and conceptual models into land use plans, monitoring plans, and other resource allocation decisions.

2) What is the location and abundance of priority renewable resources (both terrestrial and aquatic) within the field office?

Section 201(a) of the Federal Land Policy and Management Act (43 U.S.C. 1711) mandates the BLM maintain current resource inventories. Baseline inventories of priority resources are needed for RMPs, to inform management decisions, and to address emerging issues such as climate impacts. Priority resources addressed in this strategy are vegetation, including rare plants, and lotic and lentic resources, including springs and brooks. These inventories inform understanding of ecosystem capacity and constraints and are vital to document current condition, determine appropriate authorizations and uses, and identify priority areas for conservation.

Inventory data should be spatially explicit and stored to accommodate retrieval for tabular and geospatial analyses. Resource data should be collected using a "collect once, use many times" philosophy and available from a common repository.

The AIM Strategy

To address this question, the AIM Strategy supports:

- Improvement and stewardship of geospatial data layers, including land cover, soils, ecological sites, and riparian and aquatic resources.

Additionally, the AIM Strategy supports:

- Centralized collection, storage, and distribution of BLM data layers through the Geospatial Services Strategic Plan (GSSP); and
- Accessibility of national datasets collected and managed by other agencies.

3) What is the status and trend of priority renewable resources (both terrestrial and aquatic) within the field office?

The BLM uses monitoring information to comply with regulatory requirements, determine status and trend of resources, and determine the effectiveness of management actions. The BLM has limited funding to accommodate detailed, field-based monitoring on all federal lands, so monitoring efforts must be prioritized. Local monitoring requirements are established in several ways:

- Compliance for NEPA or mitigation for permit authorizations;
- Biological opinions and recovery plans;
- Commitments established within RMPs;
- Effectiveness of vegetation treatments; and
- Status and trend of priority management areas.

Data collected to meet these monitoring requirements must be quantitative, statistically valid, and reliable at multiple scales. To this end, a background, low-intensity network of quantitative monitoring is necessary. Locally, sampling must be intensified where managers need defensible data regarding resource status and trend or where priority resource questions or management objectives need to be addressed. The following examples describe priority areas: wild horse herd management areas, grazing allotments, areas of management concern, habitats supporting high-value resources, National Landscape Conservation System (NLCS) units, energy basins, and land treatments. However, related monitoring data can be used to answer a variety of questions.

The AIM Strategy

To answer this question, the AIM Strategy supports an integrated monitoring approach. This approach recognizes the utility of using legacy data (utilization, photo, trend, plot, etc.) to inform present and future decisions. Moving forward, a core set of quantitative data will be collected using a statistically valid sampling framework, standardized methods, field data collectors with standardized upload capabilities, and storage in a sharable geospatial database. These data will be used to determine condition and trend at the regional scale and will also be used, in part, to train remote sensing imagery for developing geospatially explicit maps to detect landscape-level changes. The sample framework will be intensified in priority areas where a higher level of detail is needed. In summary, this integrated monitoring approach will:

- Capture legacy data in a digital format (i.e., LTDL);
- Allow for data to be collected once and used many times for many purposes;
- Provide comparable and consistent data that can be shared across all levels of the Bureau;
- Focus quantitative monitoring activities on priority management questions using a robust sampling framework and intensified sample points in priority areas; and
- Incorporate remotely sensed monitoring to provide seamless information between the high priority areas and the larger landscape.

The AIM Strategy

4) Are management actions (e.g., land treatments) moving resources toward desired conditions or resource objectives identified in RMPs?

To achieve resource objectives, or move toward achievement, it is necessary to employ effective management actions at both site and broader scales. Developing a process to evaluate the effectiveness of management actions will allow BLM managers to characterize successful treatments from failures and allow for adaptive strategies to improve future success outcomes.

Effectiveness monitoring requires integration of remote sensing, field work (via quantitative measurements and consistent methods), and landscape and other metrics to assess outcomes. Together, these methods will provide a landscape-wide approach to evaluate the effectiveness of land treatments and provide essential information for understanding effects to ecosystem capacities and incorporate adaptive management strategies. The proposed strategy will satisfy OMB's request to evaluate the effectiveness of the RMP (e.g., by determining if riparian condition is moving toward the condition described in the RMP). This will also satisfy the Government Accountability Office's (GAO) emergency stabilization and rehabilitation reporting requirements, which are designed to determine the effectiveness of the BLM's postfire treatments. Both the OMB and GAO require the BLM to collect quantitative measures to monitor the effectiveness of management actions.

The AIM Strategy

To answer this question, the AIM Strategy supports:

- Developing a treatment data standard and geospatial database that is complimented by the LTDL;
- Developing a monitoring data standard and geospatial database;
- Developing geospatial tools to analyze the effectiveness of our decisions at the RMP and regional scales; and
- Implementing GSSP to provide seamless geospatial monitoring data to all levels of the Bureau.

5) Are BLM-administered lands meeting land health standards?

The BLM requires information on land health and condition to comply with regulatory requirements, such as the Federal Land Policy and Management Act, National Environmental Policy Act, and 43 CFR 4180.1 "to sustain the health, diversity, and productivity of public lands." Land health standards (LHS) assessments and evaluations can help fulfill the statutory requirement by setting resource management plan objectives in accordance with desired future condition. LHS assessments and evaluations determine if areas are meeting standards.

The BLM is developing the ability to map and report the results of LHS evaluations at the pasture and allotment level. LHS assessments require considerable interdisciplinary time, posing challenges to managers faced with limited staff and resources to conduct this work. Therefore, the BLM must adopt an integrated approach to complete LHS assessments. This approach would use interdisciplinary teams supported by remote sensing analyses to assess high priority areas. In other areas, remotely sensed information will be the primary resource for land health evaluations.

The AIM Strategy

To answer this question, the AIM Strategy supports the Division of Rangeland Resources to:

- Develop guidance to focus assessments on priority landscapes, watersheds, and/or special management areas;
- Revise the Allotment Categorization Process to align work in priority areas;
- Coordinate LHS assessments and proper functioning condition assessments using a full, qualified interdisciplinary team;
- Use core indicators and standard methods for quantitative data collection to validate assessments and determine trend of priority resources;
- Develop and integrate remote sensing and field-based tools to detect change in land cover composition; and
- Manage data in an enterprise architecture environment.

Field Office/Region Level

6) What is the condition of habitats for species of management concern?

In order to achieve sustainability of public lands, meet habitat quality LHS, and maintain subsistence population objectives, the BLM is committed to maintaining fish, wildlife, and native plant communities on the public lands and strategically restoring degraded ones. Understanding the condition of habitat or population variables, especially for species of management concern, is essential for prioritizing habitat conservation and restoration work. Furthermore, understanding habitat condition or population variables can help determine if the Bureau is meeting its legal and regulatory obligations as set forth in the Endangered Species Act. The AIM-integrated monitoring approach will provide data needed to describe the condition of habitats used by major species.

In 2009, the BLM partnered with the Heinz Center, U.S. Fish and Wildlife Service (USFWS), state wildlife agencies, and partners to identify wildlife-based conservation targets and performance indicators. State wildlife action plans will be updated to incorporate the conservation targets and performance indicators and, where possible, will be incorporated into the integrated approach.

The AIM Strategy

To answer the habitat condition question, the AIM Strategy supports:

- Development of a statistically based sample design for quantitative data collection in priority habitats;
- Identification and incorporation of supplemental (in addition to "core") indicators as appropriate to incorporate wildlife-based conservation targets (populations or habitats) and subsistence objectives; and
- Coordination with the Heinz Center and state wildlife agencies to develop landscape metrics for monitoring priority habitat trends.

7) What are the cumulative effects of management actions?

Understanding cumulative effects is essential to understand the extent and consequences of past, present, and reasonably foreseeable future authorized, unauthorized, and natural disturbances. Evaluating cumulative effects of management actions across temporal and spatial scales allows for an assessment of landscape change to understand the consequences of both natural and unnatural changes in relation to ecosystem capacity. Determining cumulative effects will require integration of a suite of quantitative measurements collected using a statistically valid sampling framework, remote sensing, and landscape metrics. The application of this approach to determine cumulative effects will lead to more informed decisionmaking.

The AIM Strategy

To answer this question, the AIM Strategy supports:

- Development of geospatial layers to map past, present, and future resource use;
- Development of tools to detect and map disturbance and reclamation activities using quantitative measurements and remote sensing; and
- Development of tools to analyze cumulative effects in relation to ecosystem capacity.

Region Level

8) What is the extent and trend of vegetation communities relative to potential in the ecoregion?

Knowing vegetation distribution, abundance, and trend relative to potential is critical to the BLM's management of public lands. Potential vegetation must be reconciled against current and projected environmental conditions. This vegetation information provides a basis for capacity assessments when developing RMPs and are vital components for: performing habitat analysis at the site and landscape scale; analyzing vegetation patterns to determine patch size and connectivity; establishing baseline information for the development or enhancement of regional and national datasets, such as the National Land-Cover Dataset (NLCD) and Landscape Fire and Resource Management Planning Tools (LANDFIRE); indentifying offsite mitigation opportunities; and aggregating data for national-level land condition reporting.

The AIM Strategy

To answer this question, the AIM Strategy supports:

- Complete soil and ecological site mapping;
- Improvement of the national land cover map through BLM stewardship of Westwide grass and shrubland data in coordination with the Multi-Resolution Land Characteristics Consortium;
- Collection of soil and vegetation data that can be used for many objectives (e.g., land use allocations, condition reporting, land cover mapping, ecological state mapping, etc.);
- Development of tools for remotely sensed change detection and vegetation cover modeling, mapping, and analysis for use at multiple scales; and
- Management of data in an enterprise architecture environment.

9) What is the status of resources and/or resource stressors in an ecoregion?

Regional assessments are a useful landscape conservation planning tool that will allow agencies to assess the status, trend, and risk to plant communities, wildlife species, habitats, and water resources across broad spatial extents. Regional resource status is important to determine where intact landscapes occur, and therefore, where landscapes could be designated for conservation or restoration activities. Regional information is also valuable to direct funding and staff to designated areas and for consistency in analysis and decisionmaking. Fortunately, there are significant amounts of data available for regional assessments on public lands. The synthesis of these data will facilitate regional conservation strategies and cumulative-effects analysis needed for local planning, decisionmaking, and priority setting.

In December of 2007, the BLM Director accepted the Level III Ecoregion framework (Omernick 1987) as a standard for broad-scale landscape assessments, reconfirming the utility of the multiagency memorandum of understanding signed in 1996 (McMahon et al. 2001). Since acceptance of the Level III Ecoregions, the BLM (along with states, districts, and federal and nonfederal partners and stakeholders) has been developing the capacity to conduct rapid ecoregional assessments (REAs) in 12 to 18 months based on existing data. REAs will allow BLM managers and partners to: (1) develop regional strategies for conserving and restoring native plant communities and wildlife habitat; (2) develop a consistent approach to prioritize and fund projects; (3) identify areas where multiple-use conflicts are low and the potential for energy development is high; and (4) examine the cumulative effects of BLM management decisions on regional, cross-jurisdictional landscapes.

The AIM Strategy

To answer this question, the AIM Strategy supports:

- Implementing GSSP, including the development of Bureauwide data standards and centralized collection, storage, and distribution of BLM geospatial data;
- Developing a process for incorporating REA results into the designation of priority areas for monitoring; and
- Managing data in an enterprise architecture environment.

National Level

10) What are the location, abundance, and trend of renewable resources on lands administered by the BLM?

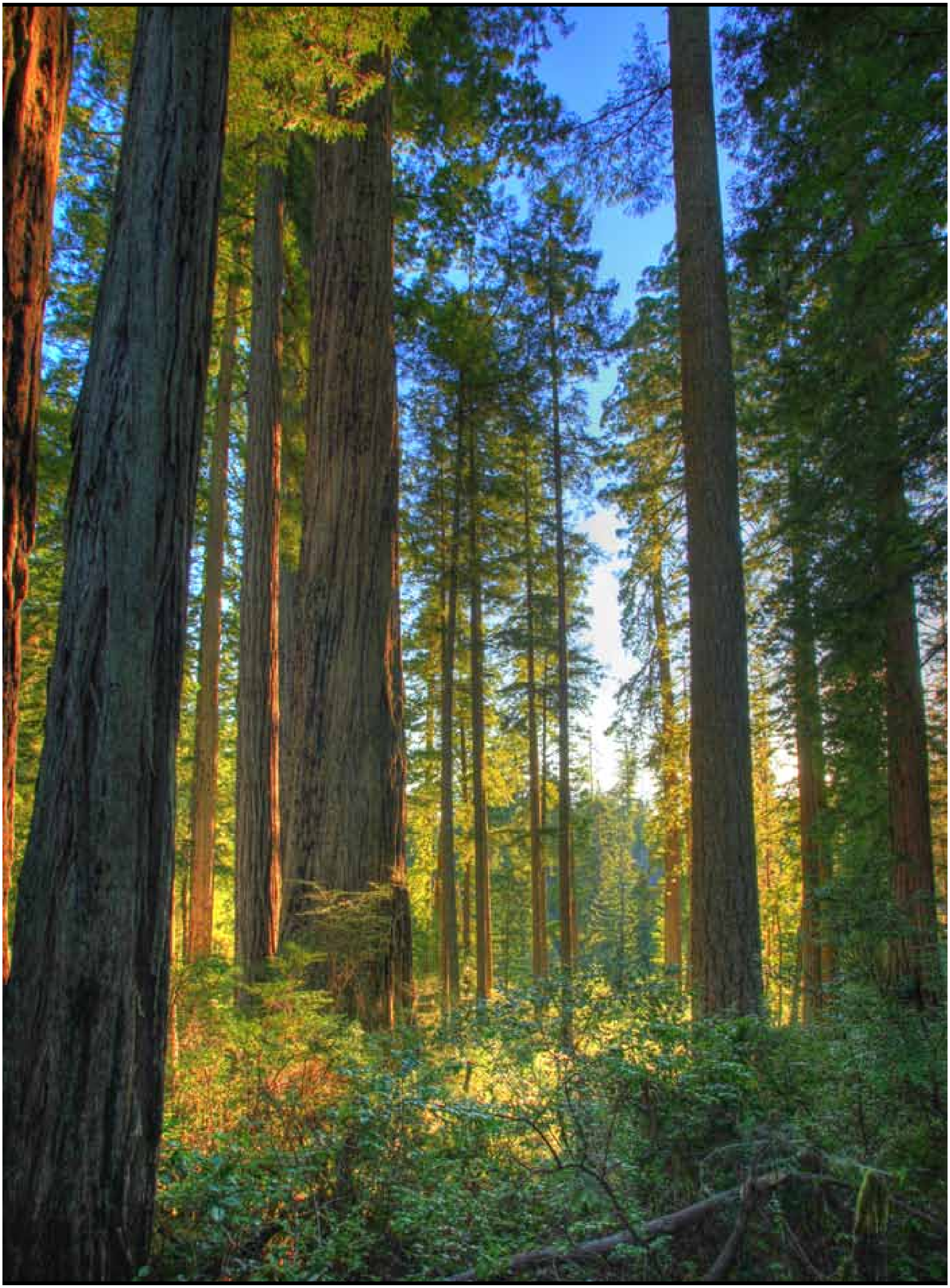
Effective national policy development, congressional budget direction and appropriations, and sustainable BLM land use allocations require an understanding of extent, trend, and ultimately, capacity of natural resources. To accommodate national-level reporting, the integrated monitoring approach described in this strategy is based on the ability to aggregate quantitative data and remote sensing to report distribution, abundance, and trend of priority resources.

The AIM Strategy

To answer this question, the AIM Strategy supports:

- Implementing a statistically valid, "extensive" sampling framework across all federal, nonforested lands where the core indicators will be monitored in coordination with the NRCS;
- Ensuring consistency and compatibility with existing national-level reporting on vegetation extent and trend; and
- Developing national-level reports based on the integrated approach.

The AIM Strategy recognizes that management questions exist beyond those that have been addressed here. Management priorities may change, new issues will emerge, and additional analysis tools will be required. As such, the intent is for this strategy to be a living document.



Sound and consistent land management decisions are supported by accurate, well defined, and trusted data that are managed in an effective and efficient manner (BLM 2009a).

– BLM Data Management Vision

Data acquired in support of the AIM Strategy and other related BLM activities will need to be maintained, analyzed, updated, and available for use now and into the future. Monitoring data present an especially sensitive data management challenge because the integrity and reliability of the data must be maintained if resource trends are to be established. To study status and trends of land management activities, analysts will need access to data collected previously, as well as current data. Acquisition and management of standardized data will enable the BLM to determine if public lands are moving toward desired conditions or resource objectives.

Data Acquisition

Effectively and efficiently answering each of the focal management questions requires a multiscale, coordinated, and integrated approach within the Bureau. An integrated approach for data acquisition will afford an opportunity to collect data once and use them many times for many purposes. The three fundamental data acquisition processes described in this section include: (1) development and application of core quantitative indicators and consistent methods for monitoring; (2) implementation of a statistically valid sampling framework; and (3) application and integration of remote sensing technologies. Working in concert, these processes, or data elements, provide a foundation for an integrated data acquisition approach that will provide the quantitative data essential for informed, defendable land management decisionmaking.

Core Indicators and Consistent Methods

The BLM has begun the process to standardize resource data collection by identifying a core set of terrestrial and aquatic indicators and methods. The goal is to establish core quantitative indicators that can be applied across all lands and ecosystems managed by the BLM, for example grasslands, shrublands, woodland savanna, tundra, forests, and riparian. The core indicators are intended to be collected and then used many times for many purposes. These indicators and methods can be used for the measurement and analysis of key ecosystem attributes and for determining terrestrial and aquatic status. The indicators also allow for comparable data to be collected and reported across offices and at multiple levels within the Bureau. Furthermore, most of the core indicators and methods are compatible with standardized monitoring efforts being used nationwide by other agencies (e.g., NRI used by the NRCS and FIA used by the USFS), allowing for potential cross-agency integration of efforts and reporting in the future. The data collected via core indicators and methods may also be used in conjunction with remotely sensed imagery (e.g., as a basis for training and ground-truthing) to enhance vegetation-based land cover mapping, such as the NLCD, Gap Analysis Program (GAP), and LANDFIRE.

The terrestrial indicators were selected based on interdisciplinary input from all levels of the BLM and in collaboration with federal scientists, academic scientists, and nongovernmental organizations (e.g., Heinz Center and Sustainable Rangelands Roundtable) familiar with national status and trend indicators (Herrick et al. 2010). The core indicators are useful, objective, transparent, quantitative, and reproducible. A full explanation of the terrestrial indicators can be found within BLM Core Terrestrial Indicators and Methods (MacKinnon et al. 2011). The indicators include:

Terrestrial Core Indicators

1. Bare ground
2. Vegetation composition
3. Nonnative invasive plant species
4. Plant species of management concern
5. Vegetation height
6. Proportion of soil surface in large intercanopy gaps

Terrestrial Contingent Indicators (Used Where Applicable)

7. Soil aggregate stability
8. Significant accumulation of soil toxins

The aquatic core indicators will be vetted through a similar process as the terrestrial indicators and are subject to change based on the outcome of this collaborative review.

Proposed Aquatic Indicators
1. Temperature
2. Macroinvertebrate ratio
3. Bankful width
4. Stream gradient
5. Streambank stability
6. Residual pool depth

In addition to the terrestrial core and proposed aquatic indicators, field office managers and staff may add supplementary indicators to address specific resource questions, such as the population of a particular wildlife species or a particular land degradation or recovery process.

Core terrestrial field-collection methods include the line-point intercept, supplemented with vegetation height and a plot-level species inventory, and intercanopy gaps (all which can be collected in conjunction with the point-intercept data). Furthermore, remote sensing can be used to generate comparable results for terrestrial indicators 1-4 and 6 for creating spatial predictions to be used in landscape-scale assessments and management plans. Proof-of-concept testing for the application of the core indicators and methods is currently underway, under three different scenarios at varying scales—an NLCS unit, a wild horse and burro herd management area, and an energy basin. Utilizing the consistent methods to collect the core indicators is critical to implementation of the AIM Strategy; differences among different methods (e.g., foliar vs. canopy cover) for the same indicator can compromise the ability to combine data (MacKinnon et al. 2011).

Statistically Valid Sampling Framework

For the core indicators and methods to provide defensible resource information at multiple scales a georeferenced, statistically valid (i.e., probability-based) sampling framework is necessary. The BLM is working with ARS, NRCS, and USGS scientists to extend the NRI sampling framework to all BLM lands. This sampling framework consists of a low-intensity national grid that can be intensified for local monitoring needs or supplemented with other probability-based samples, all of which can be used to train remote imagery. Intensifications of this sampling design will be implemented initially for sage-grouse habitat monitoring and as a foundation for improving shrub and grassland vegetation mapping. The three proof-of-concept sites for the core indicators will also provide demonstration of how other BLM local sampling datasets can be combined with the national grid. The design will meet two key requirements for data scaling: (1) to be spatially unbiased and (2) to have a nonzero sampling probability (every point on the landscape has at least some small, but known, chance of being sampled). Where possible, the sampling design will also accommodate the location of relevant BLM monitoring sites (e.g., key area, legacy long-term trend sites, rare plant populations, etc.) that continue to provide information for areas of management concern.

Developing an unbiased, statistically valid sampling framework will allow data collected at specific sites to be scaled to larger management units (e.g., allotments or NLCS units), watersheds, or landscapes identified for monitoring. It will also permit locally collected data to be combined with regional- or national-level data to improve estimates at larger scales. Further, the framework will provide the ability to defensibly answer resource questions about large tracts of land, with relatively few sample locations, and allow for sample-site relocation if an original site is disturbed (by energy development, for example).

Remote Sensing

The core indicators and methods provide the foundation to ensure a successful monitoring strategy. The core indicators will also provide information essential to train and validate remote sensing-derived data. The field-based measurements alone do not address the need to describe resource extent and distribution across vast expanses of land, but when combined with remote sensing products, this critical need can be addressed. To meet the full spectrum of spatial and temporal information, the AIM Strategy supports the development of integrated, scalable remote sensing tools that build on the quantitative field data described previously. Using these tools, as a component of an integrated data management strategy, the BLM can document land cover changes, cumulative impacts, unauthorized disturbances, and land treatment activities at the field, regional, and national scale. By integrating remote sensing into the overall AIM Strategy, we can better leverage the field-based monitoring data to ensure the development of mapping products that would otherwise be too expensive to generate independently.

The foundation for this remote sensing approach will be documented in the BLM's Remote Sensing Concept of Operations Plan (CONOP), which is currently in development at the National Operations Center. The goal of this plan is to provide a suite of remote sensing tools to support BLM information needs at multiple temporal and spatial scales. These tools will not be developed as discrete products but as a suite to maximize usage of limited resources while addressing multiple needs. That is, instead of a remote sensing project being designed for a single use, it will reflect long-term remote sensing activities that mirror the strategic goals of the Bureau.

This multiscale, multiuse remote sensing approach is demonstrated in the integration of the following three tools: (1) Fine Scale: Small Unmanned Aerial System (UAS) Program, (2) Moderate Scale: Grassland/Shrubland Stewardship, and (3) Coarse Scale: Regional Ecological Land Monitor (RELM). Each of these program areas is an independent tool; however, it is the interrelationships within the programs where the real value to the Bureau can be realized. As the Small UAS Program builds over time, more and better field data will feed into the Stewardship Initiative, thus helping to improve the quality of national land cover products. As national land cover products improve, the data and models within RELM will improve. As the high temporal resolution data found in RELM improves, the more likely the BLM can use RELM as a proactive monitoring and field prioritization tool. In turn, the BLM will have better information for planning future UAS missions, and the cycle will repeat.

In prioritizing the three remote sensing tools, improving the grassland/shrubland cover map is the need most often requested by field offices and is supported by the AIM Strategy as a national priority for integrated vegetation management. Shrub and grasslands within existing land cover/vegetation mapping datasets (i.e., LANDFIRE, ReGAP, and NLCD) are currently characterized as only general classes and lack sufficient detail to meet BLM information requirements for planning or decisionmaking. To address this problem, the BLM must assume an active role in stewardship of the grassland/shrubland data in partnership with the Multi-Resolution Land Characteristics Consortium. Stewardship will provide more accurate, finer-scale land cover information needed for resource planning. Additionally, stewardship will facilitate improvements to LANDFIRE and the NLCD, which will promote wider acceptance and use of these national datasets.

As mentioned in the Remote Sensing CONOP, the UAS and RELM have tremendous potential to be cost-effective methods for the BLM to leverage monitoring data. A UAS (i.e., small unmanned aircraft) or other source of very high resolution aerial imagery could provide the BLM with relatively quick and inexpensive collection of imagery to meet local and plot-level data needs. Recent projects have demonstrated that UAS can be used to sample large landscapes effectively to: (1) generate estimates of rangeland attributes consistent with field-based measurements (Booth and Cox 2008; Duniway et al. 2011) and (2) support broader-scale remote sensing efforts. RELM will provide the BLM with access to a suite of remote sensed products that would otherwise not be available to resource specialists. The goal of RELM is to make information products developed by the National Oceanic and Atmospheric Administration, USGS, NASA, and others available in an easy-to-use Web interface. RELM will provide resource managers with near-real-time, regional information products allowing users to: visualize and assess landscape-scale rangeland status via historic and current vegetation greenness trends, prioritize restoration areas based on current data, assess treatment success across multiple temporal scales, determine optimal time for grazing activities, and assist in maximizing fuel treatment activities.

Data Management

Data acquired in support of the AIM Strategy and other related BLM activities will need to be maintained, updated, and available for use now and into the future. Monitoring data represent a data management challenge because the integrity and reliability of the data must be maintained through time if reliable resource trends are to be established. Effective data management will enable the BLM to determine if public lands are moving toward desired conditions or resource objectives at multiple scales.

AIM Strategy Data Management Objectives

- Provide confidence in the integrity, security, and availability of monitoring data and metadata;
- Ensure easy access to information across all levels of the organization, while ensuring appropriate safeguards for sensitive information;
- Provide awareness of the intended use and limitations of each dataset;
- Accommodate infrastructure and documentation to encourage data exploration and sharing;

- Facilitate compatibility of datasets for analysis and integration;
- Ensure continuity of data for long-term needs, such as changing climatic conditions or treatment effectiveness monitoring; and
- Administer a proper balance between the standards needed to ensure quality and usability and the flexibility to meet business requirements.

Data Standards

Data standards refer to the name, definition, presentation, and business rules governing data sets. They are based on the known data requirements and are set by the stakeholders who need the data. As such, they can cross organizational boundaries (BLM 2002).

– BLM Manual Section 1283, Data Administration and Management

Standards ensure that data crossing programs and business lines, for different uses, are compatible. The first step to develop a data standard for vegetation, soils, and water resources was the development of a business process model that identified the data structure, metadata, and common workflow elements. The model was used to develop a data standard and repeatable data management processes for aquatic environments (i.e., riparian areas). Efforts are currently underway to develop data standards for quantitative monitoring of terrestrial environments (vegetation communities) and for vegetation treatments. Combined, these data standards provide an integrated approach for monitoring terrestrial and aquatic environments across multiple scales and administrative boundaries.

Data standards and geospatial technologies are essential for BLM data management and analyses. From documenting and protecting resources, to providing logistical and tactical support for wildland fires, to evaluating potential use authorizations, geospatial technologies are integral to successful land management. Therefore, the AIM Strategy promotes the implementation of data standards and geospatial technologies through the GSSP.

Geospatial Services Strategic Plan

A spatially enabled Bureau supporting accurate and effective decisions means that the BLM must have data and processing capabilities available to support day-to-day business. Data can come from internal or external sources, and should be accessible electronically and, in most cases, on the Web (BLM 2008a).

– GSSP Vision

The GSSP charts a course for the integration and use of geospatial data through adoption of an Enterprise Geographical Information System (EGIS). EGIS affords the opportunity for virtual, centralized access to geospatial data across the BLM. The goal is to implement EGIS for all BLM offices to facilitate aggregation of data to meet local, regional, and national needs. The GSSP provides the technological foundation that will support the implementation of the data management objectives of the AIM Strategy and will support regional- and national-level reporting. Through GSSP efforts, the links between information technology, GIS, and business requirements are being addressed as an integrated whole.

BLM Corporate Datasets in the GSSP

A central tenant of the GSSP acknowledges the majority of the data the BLM manages is local in nature, and any centralized solution must provide the field with tools to maintain this data. This model requires all parties to follow the published data standards and data management procedures. While additional BLM corporate datasets are essential, those that are completed, or in development, include the following:

- **Cadastral datasets:** Public Land Survey System, state boundaries, surface management areas, and county boundaries;
- **Administrative and management unit boundaries:** BLM administrative units, land use planning areas, Taylor Grazing Act district boundaries, NLCS areas, areas of critical environmental concern, grazing allotments and pastures, and wild horse and burro herd areas and herd management areas; and
- **Resource datasets:** invasive species (infestations areas, survey boundaries, weed management areas, treatment boundaries), ground transportation linear features, vegetation treatment areas, high priority sage-grouse habitat, Visual Resource Inventory, resource improvement locations, and riparian areas.

Corporate datasets support AIM Strategy objectives by providing foundational data to describe resource extent and location and nature of authorized uses. To determine the condition and trend of resources and the effectiveness of the BLM's management actions, analyses using quantitative monitoring data in conjunction with corporate geospatial data are required. The GSSP is critical to achieve this need.

External Datasets

Working collaboratively with other federal partners (e.g., NRCS, USGS, USFS, and USFWS), the BLM is participating to complete and enhance geospatial datasets commonly used for public land management decisions. Additionally, there are numerous geospatial datasets that are accessed from other federal, state, and local partners. By overlaying internal and external resource datasets (e.g., vegetation, hydrology, and ecological sites) with data on natural and human-induced stressors (e.g., wildfire, invasive species, climate change, and development), robust and complex analyses of resource use and effects are possible across multiple scales.

External datasets support AIM Strategy objectives by providing data that are essential for land management decisions, but beyond the scope of the BLM. Critical external datasets the BLM should contribute to and participate in stewardship of include: vegetation (field and remote), soils, ecological site descriptions, National Hydrography Dataset, and National Wetlands Inventory.

Currently, the BLM is compiling datasets for REAs using the above corporate layers and many external data sources from states and federal and nonfederal partners. These datasets will evolve as REAs are completed and serve as valuable tools to spatially document ecological conditions and disturbance regimes and describe cumulative impacts within ecoregions.

Legacy Data

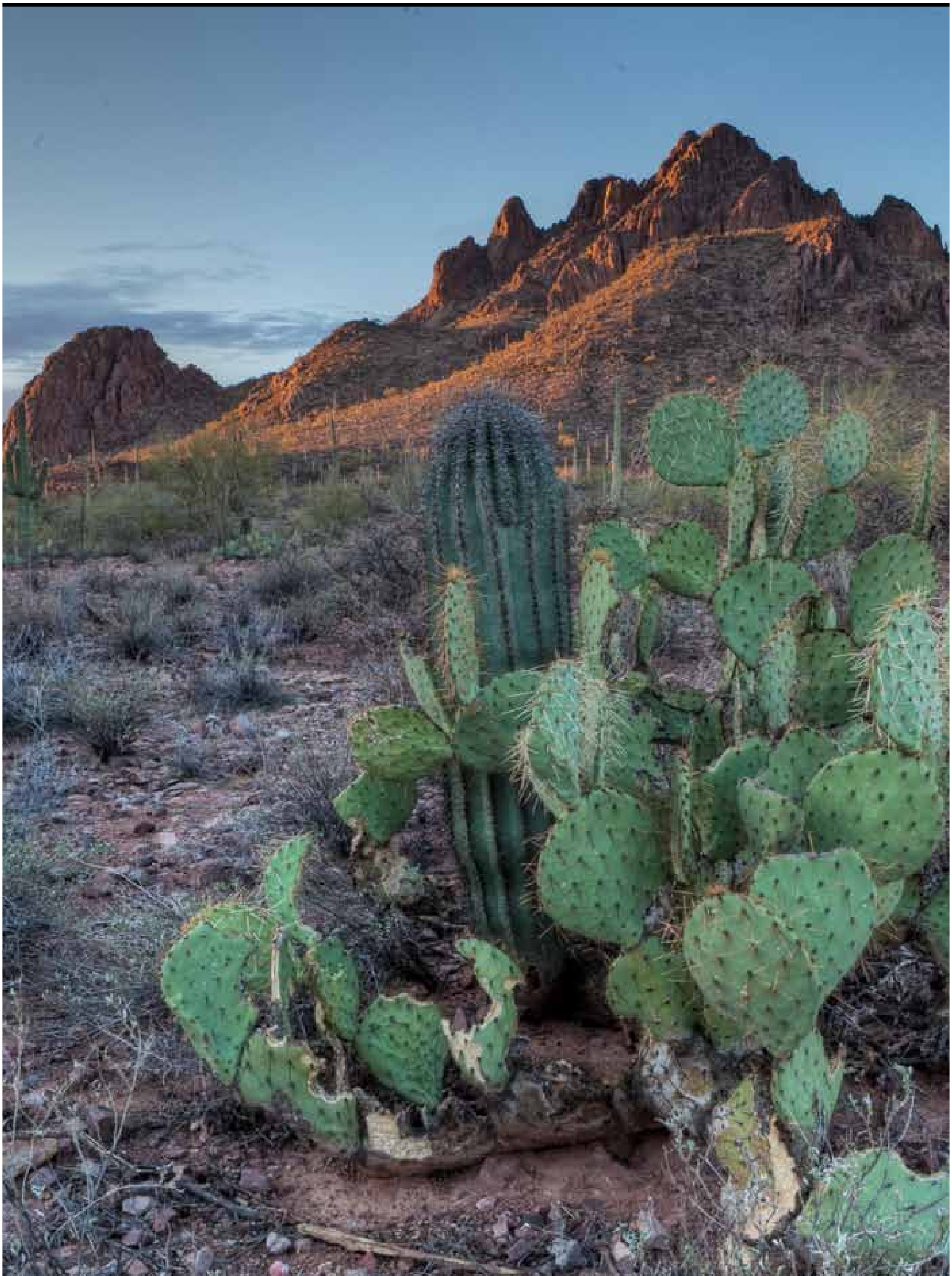
The BLM has a substantial historical record of land treatments and vegetation monitoring data that resides in field offices, commonly in paper format and at risk of being lost. These historical data represent enormous value to the BLM, but are currently of limited use (due to nature of the storage) and inaccessible to a wider community. In 2007, the USGS completed the archiving of land treatment data from 10 BLM field offices with initial funding from the Integrated Landscape Monitoring Pilot Project and the Joint Fire Science Program. Success of this pilot effort has led to the development of the LTDL.

The AIM Strategy supports the compilation of land treatment legacy data into the LTDL from all BLM field offices. Once compiled, these scanned data can be queried, retrieved, mapped, and synthesized for planning, fire management activities, and project-level activity planning and future scenario planning.

To build on the legacy information in the LTDL, the BLM is developing geospatial databases to capture historical, current, and future treatments areas; treatment attributes; and associated monitoring data. Where they continue to be useful, properly documented and georeferenced legacy treatment and trend monitoring data (and all current and future monitoring data) will be entered into a monitoring geodatabase.

Field Data Collection

Historically, the BLM's data have been collected and stored on hardcopy forms and remain at the field office where the data were collected. The AIM Strategy is moving the BLM toward a new paradigm where monitoring data is based on core indicators and methods, collected in the field on tablet computers, and stored digitally. These changes will ensure greater integrity of the data, reduce workloads and the potential for transcription errors (by removing the need to transfer hardcopy information to digital), and facilitate data sharing and access across the Bureau. To realize this new field-collection paradigm, the AIM Strategy supports the integration of the ARS Database for Inventory, Monitoring and Assessment with a standard collection protocol for capturing core monitoring data. To integrate this as a Bureauwide solution supported by the EGIS platform and the GSSP, a corporate geospatial database will be created to serve as an enterprise solution for managing resource data.



Next Steps

The AIM Strategy was an OMB-initiated project, but the BLM soon realized the high value the strategy could offer in coordinating monitoring activities to address resource issues at multiple scales. This AIM Strategy presents a vision to harness decades of good quality field work and move forward in a strategic, coordinated fashion by standardizing protocols and incorporating current technologies to address resource questions. The strategy also provides a vision for the BLM to move forward from hardcopy data capture to an integrated, multiscale approach that incorporates ecological models, site data, and imagery.

To integrate this vision and the associated work processes (e.g., integrated data collection and management; core indicators, methods, and sampling framework; and remote sensing) into the fabric of the Bureau, the BLM will develop an implementation plan. This plan will establish work products, timelines, and responsible parties to update and develop cross-program guidance, determine output and outcome performance measures, train renewable resource staff in this integrated approach, and focus funds in priority areas (e.g., watersheds) for conservation and restoration. This plan will be periodically reviewed and updated.

Moving forward, WO-200, Renewable Resources and Planning, will establish an AIM Coordination Team to work with field office, state office, and center staffs and Washington Office program leads to create an implementation plan.

List of Acronyms

AIM	Assessment, Inventory, and Monitoring
ARS	Agricultural Research Service
BLM	Bureau of Land Management
CEQ	Council on Environmental Quality
CONOP	Concept of Operations
EGIS	Enterprise Geographical Information System
FIA	Forest Inventory and Analysis
GAP	Gap Analysis Program
GSSP	Geospatial Services Strategic Plan
LANDFIRE	Landscape Fire and Resource Management Planning Tools
LHS	Land Health Standards
LTDL	Land Treatment Digital Library
NLCD	National Land-Cover Dataset
NLCS	National Landscape Conservation System
NRCS	Natural Resources Conservation Service
NRI	National Resources Inventory
OMB	Office of Management and Budget
REA	Rapid Ecoregional Assessment
RELM	Regional Ecological Land Monitor
RMP	Resource Management Plan
UAS	Unmanned Aerial System
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

abundance: the total number of individuals of a species in an area, population, or community (SRM 1999).

adaptive management: (1) a system of management practices based on clearly defined outcomes, monitoring to determine if management actions are meeting outcomes, and, if not, facilitating management changes that will best ensure that outcomes are met or re-evaluated (BLM 2008c); or (2) an iterative learning process producing improved understanding and improved management over time….[that] promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a “trial and error” process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals; increases scientific knowledge; and reduces tensions among stakeholders (Williams et al. 2009).

allotment: (1) the basic geographic area used in administering BLM rangeland (BLM 2009b); or (2) an area of land designated and managed for grazing by livestock. Such an area may include intermingled private, state, or federal lands used for grazing in conjunction with the public lands (Habich 2001).

assessment: the estimation or judgment of the status of ecosystem structures, functions, or processes within a specified geographic area (preferably a watershed or group of contiguous watersheds) at a specific time. An assessment is conducted by gathering, synthesizing, and interpreting information from observations or data from inventories and monitoring. An assessment characterizes the status of resource conditions so that the status can be evaluated (e.g., relative to land health standards) (BLM 2008c).

attribute: (1) one of the three components, soil/site stability, hydrologic function, and biotic integrity, that collectively define rangeland health (Pellant et al. 2005); or (2) an inherent characteristic (Merriam-Webster Online 2011); or (3) any living or nonliving feature or process of the environment that can be measured or estimated and that provides insights into the state of the ecosystem. The term indicator is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2003). See indicator.

bare ground: all land surface not covered by vegetation, rock, or litter (Habich 2001).

biotic integrity: capacity of a site to support characteristic functional and structural communities in the context of normal variability, to resist loss of this function and structure due to a disturbance, and to recover following such disturbance (Pellant et al. 2005).

climate: composite or generalized weather conditions of a specific region, such as temperature, pressure, humidity, precipitation, sunshine, cloudiness, and winds, averaged over a series of years.

composition: the proportions of various plant species in relation to the total on a given area; it may be expressed in terms of cover, density, weight, etc. (SRM 1999).

conceptual model: purposeful representation of reality that provides a graphical depiction of how something works to communicate that explanation to others (NPS 2006).

cover: (1) the proportion of the soil surface covered by a vertical projection of the cover class of interest (e.g., canopy cover, basal cover, litter cover), regardless of what is above or below the object (Pellant et al. 2005); or (2) the percentage of material, other than bare ground, covering the land surface. It may include live and standing dead vegetation, litter, biological crust, cobble, gravel, stones, and bedrock. Ground cover plus bare ground would total 100 percent (Pellant et al. 2005).

degradation: changes [to ecological attributes] that reduce ecological integrity and health (Clewell et al. 2002).

driver: the major external driving force that has large-scale influences on a natural system. Drivers can be natural forces or anthropogenic (NPS 2006).

ecological process (or ecosystem functions): the dynamic attributes of ecosystems, including interactions among organisms and interactions between organisms and their environment. Ecological processes are the basis for self-maintenance in an ecosystem. Ecosystem functions and processes, along with the reproduction and growth of organisms, are what cause an ecosystem to be self-renewing (BLM 2008c).

ecological site: a kind of land with a specific potential natural community and specific physical site characteristics, differing from other kinds of land in their ability to produce distinctive kinds and amounts of vegetation and to respond to management (Habich 2001).

ecological site description: description of the soils, uses, and potential of a kind of land with specific physical characteristics to produce distinctive kinds and amounts of vegetation (BLM 2008c).

ecosystem: (1) a spatially explicit unit of the earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries (NPS 2006); or (2) organisms together with their abiotic environment forming an interacting system and inhabiting an identifiable space (Habich 2001).

effectiveness monitoring: the process of collecting data and information in order to determine whether or not desired outcomes (expressed as goals and objectives in the land use plan) are being met (or progress is being made towards meeting them) as the allowable uses and management actions are being implemented (BLM 2005).

functioning: refers to the presence and integrity of ecological processes (energy flow, water cycling, and nutrient cycling) being within the range of expectations for the ecological site (Pellant et al. 2005).

habitat: a place where an animal or plant normally lives for a substantial part of its life, often characterized by dominant plant forms and/or physical characteristics (BLM 2008c).

health: see rangeland health.

hydrologic function: the capacity of the site to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant); to resist a reduction in this capacity; and to recover this capacity following degradation (Pellant et al. 2005).

indicator: (1) component of a system whose characteristics (e.g., presence or absence, quantity, distribution) are used as an index of an attribute (e.g., hydrologic function) that is too difficult, inconvenient, or expensive to measure (BLM 2008c; Pellant et al. 2005); or (2) a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system (NPS 2006).

integrity (or ecological integrity): the ability of ecological systems to support and maintain a community of organisms that have the species composition, diversity, and functional organization comparable to those of natural habitats within the ecoregion range (or area) (Parrish et al. 2003).

invasive plants: plants that are not part of (if exotic), or are a minor component of (if native), the original plant community or communities that have the potential to become a dominant or co-dominant species on the site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants (BLM 2008c; Pellant et al. 2005).

inventory: (1) gathering of baseline information (including quantitative data, cultural knowledge, and qualitative observations) about condition of resources (BLM 2001; BLM 2008c); or (2) the systematic acquisition and analysis of resource information needed for planning and management purposes (Pellant et al. 2005); or (3) an extensive point-in-time survey to determine the presence/absence, location, or condition of a biotic or abiotic resource (NPS 2006).

land use plan: a set of decisions that establishes management direction for land within an administrative area, as prescribed under the planning provisions of the Federal Land Policy and Management Act; an assimilation of land-use-plan-level decisions developed through the planning process outlined in 43 CFR 1600, regardless of the scale at which the decisions were developed. The term includes both resource management plans (RMPs) and management framework plans (MFPs) (BLM 2008c).

landscape: (1) all the natural features, such as grasslands, hills, forest, and water, that distinguish one part of the earth's surface from another part; [at one scale of consideration] usually that portion of land that the eye can comprehend at a single view, including all its natural characteristics (BLM 2008c); or (2) a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout (Forman and Godron 1986) that could range in absolute scale from an area smaller than a single forest stand (or an individual log) to an entire ecoregion (McGarigal et al. 2002).

litter: the uppermost layer of organic debris on the soil surface; essentially the freshly fallen or slightly decomposed vegetal material (Habich 2001).

metadata: data about data. Metadata describes the content, quality, condition, and other characteristics of data. Its purpose is to help organize and maintain an organization's internal investment in spatial data; provide information about an organization's data holdings to data catalogues, clearinghouses, and brokerages; and provide information to process and interpret data received through a transfer from an external source (NPS 2006).

mitigation: an action that is intended to compensate environmental damage (Clewell et al. 2002).

monitoring: the regular collection of data over time to evaluate whether objectives or land health standards are being achieved and to evaluate effectiveness of management actions (BLM 2001; BLM 2008c).

native species: species that historically occurred or currently occur in a particular ecosystem and were not introduced (BLM 2008c).

natural ecosystem: one that developed by natural processes and that is self-organizing and self-maintaining.

normal range of variability: the deviation of characteristics of biotic communities and their environment that can be expected given natural variability in climate and disturbance regimes (BLM 2008c; Pellant et al. 2005).

organic matter: living plant tissue and decomposed or partially decomposed material from living organisms (Pellant et al. 2005).

pasture: (1) an area that is a subset of an allotment (an allotment may have one or more pastures) (BLM 2009b); or (2) a grazing area enclosed and separated from other areas by a fence or natural barrier (Habich 2001).

potential (or ecological site potential): the ecological community that would be established if all successional sequences of its ecosystem were completed without additional human-caused disturbance under present environmental conditions; often referred to as "potential natural community" (Regional Interagency Executive Committee and Intergovernmental Advisory Committee 1995).

proper functioning condition: (1) condition in which vegetation and groundcover maintain soil conditions that can sustain natural biotic communities (BLM 2008c); or (2) riparian-wetland areas are functioning properly when adequate vegetation, landform, or large woody debris is present to: dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity (BLM 2008c).

quantitative: (1) collection of data by measuring vegetation or soil characteristics (Habich 2001); or (2) data derived from measurements, such as counts, dimensions, weights, etc., and recorded numerically; may include ratios or other values. Qualitative numerical estimates, such as ocular cover and production estimates, are often referred to as "semi-quantitative" (Pellant et al. 2005).

qualitative: observational data derived from visual observations and recorded descriptively but not measured (e.g., descriptive or nonnumerical data) (Pellant et al. 2005).

rangeland: land on which the native vegetation, climax, or natural potential consists predominantly of grasses, grasslike plants, forbs, or shrubs. The term includes lands revegetated naturally or artificially to provide a noncrop plant cover that is managed like native vegetation. Rangeland may consist of natural grasslands, savannahs, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows (BLM 2008c).

rangeland health: the degree to which the integrity of the soil, vegetation, water, and air, as well as the ecological processes of the rangeland ecosystem, are balanced and sustained. Integrity is defined as maintenance of the structure and functional attributes characteristic of a locale, including normal variability (SRM 1999).

remote sensing: the technique of collecting information from a distance. Most common mediums used are aerial photography and satellite imagery.

soil aggregate: a group of primary soil particles that cohere to each other more strongly than to other surrounding particles (SSSA 1997).

soil/site stability: the capacity of a site to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water (Pellant et al. 2005).

stressor: physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level (Barrett et al. 1976).

trend: (1) the direction of change in ecological status or resource value rating observed over time (Pellant et al. 2005); or (2) the directional change measured in resources by monitoring their condition over time. Trends can be measured by examining individual change (change experienced by individual sample units) or by examining net change (change in mean response of all sample units) (NPS 2006).

vegetation: plants in general, or the sum total of the plant life above and below ground in an area (Habich 2001).

water cycle: the capture, storage, and redistribution of precipitation (Habich 2001).

watershed: the total area of land above a given point on a waterway that contributes runoff water to the flow at that point. A major subdivision of a drainage basin (BLM 2008c; Habich 2001).

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