

AIM-Monitoring: A Component of the BLM Assessment, Inventory, and Monitoring Strategy

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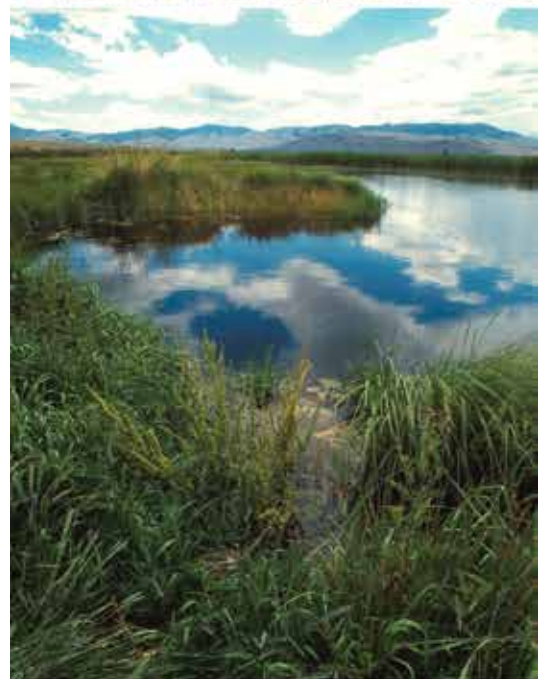
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Abstract

The “Bureau of Land Management Assessment, Inventory, and Monitoring Strategy for Integrated Renewable Resources Management” (AIM Strategy) provides high-quality information about ecosystem conditions and trends for decisionmaking. This information, or monitoring data, is essential for the Bureau of Land Management (BLM) to fulfill its multiple-use mission and sustain the diverse uses and benefits of public lands. The purpose of this technical note is to describe the monitoring portion of the AIM Strategy to support implementation across the BLM, thus addressing multiple resource questions at multiple scales. The AIM approach to monitoring features five elements: (1) a standard set of core quantitative indicators and methods, enabling easy comparison of measurements in different places and over time; (2) a defensible and statistically valid way of selecting monitoring plots that informs land management at multiple scales; (3) integration with remote sensing, providing a bird’s-eye view of conditions across the landscape; (4) electronic data capture and management, streamlining information access and application to decisions; and (5) a structured implementation process built on management questions and an understanding of ecosystems. To date, a number of demonstration projects have applied the AIM approach on BLM lands from Arizona to Alaska. These projects focus on a variety of management issues, from aquatic ecosystem health to wild horses and burros. They also address a variety of scales, from local to national. Information derived from AIM-Monitoring is collected once but can be used many times to guide land uses, policy actions, and adaptive management decisions.



Introduction: High-Quality Information

High-quality information on the status, condition, and trend of natural resources is essential for making sound land management decisions. The Bureau of Land Management (BLM) collects this information through an array of resource assessment, inventory, and monitoring efforts that support the bureau's diverse, multiple-use land management needs.

All management levels of the BLM rely on monitoring data to derive essential resource information. At the field level, monitoring information is used in developing land use and activity plans and for designing and assessing virtually all resource management projects (e.g., vegetation treatments, fire recovery efforts, livestock grazing, energy development and extraction, recreation activities, etc.). At the regional level, monitoring information is used to detect landscape-scale resource status and trend, as well as to help focus and coordinate field management efforts within and across jurisdictional boundaries. Monitoring information is also used at the national level to report on overall resource status, condition, and trend and to direct management capacity where it's most needed.

The Need for a New Monitoring Approach

BLM monitoring efforts have historically been developed to meet specific project and program objectives at the field level. However, because individual monitoring efforts were developed at different times for varied purposes, they commonly did not share standard approaches. As a result, even when current monitoring efforts fulfill local management or program-specific needs, much of the information cannot be readily compared across time or management areas, combined with monitoring data from different programs, or aggregated to provide regional or national perspectives on resource status, condition, and trend or management effectiveness. In other cases, current monitoring efforts are not fulfilling the full range of management needs.

The rate of change and the amount of use on public lands are at unprecedented levels. Deriving the knowledge of how ecosystems are changing, which is essential to guide and justify management, use, or policy actions, necessitates consistent data that can serve many monitoring objectives and can be aggregated for use across multiple scales of management (from field to national levels). Given capacity constraints and the sheer number of monitoring needs, it is no longer possible to implement individual monitoring and assessment plans for each identified threat or use.

AIM-Monitoring: A National, Integrated Monitoring Approach

The "BLM Assessment, Inventory, and Monitoring Strategy for Integrated Renewable Resources Management" (AIM Strategy) was completed in 2011 in response to a request from the Office of Management and Budget. The strategy describes an approach for integrated, cross-program assessment, inventory, and monitoring of renewable resources (e.g., vegetation, soils, water, and wildlife habitat) at multiple scales of management. Following the AIM Strategy, the BLM is modernizing its resource monitoring approach to more efficiently and effectively meet local, regional, and national resource information needs. The AIM Strategy provides a process for the BLM to collect quantitative information on the status, condition, trend, amount, location, and spatial pattern of renewable resources on the nation's public lands, from individual field office levels to public lands across the Western U.S. and Alaska. Each AIM-Monitoring survey, at any scale of inquiry, uses a set of core indicators, standardized field methods, remote sensing, and a statistically valid study design to provide nationally consistent and scientifically defensible information to track changes on public lands over time.

Benefits of using AIM–Monitoring

AIM Element	Benefit
Standard set of core quantitative indicators and methods	Standardized measurements allow easy comparison of data collected in different places and over time. By collecting the same core data across the BLM, the data can be used for many different purposes at many different scales.
Statistically valid sampling design	Statistically valid methods used to study lands enable data to inform land management decisions at many different scales, from individual grazing allotments to ecoregion and national levels. This also allows the BLM to combine data with other agencies that use statistically valid methods.
Integration with remote sensing	Remotely capturing information (for example, using satellite imagery) gives us a bird's-eye view of conditions across the landscape. Using this information increases the efficiency of BLM data collection.
Electronic data capture and management	Once monitoring data is collected for an area, it is stored in a central database and can be easily accessed and used, saving the BLM time and money.
Implementation process	A monitoring program built on management questions and an understanding of ecosystems will provide relevant and timely information to the decisionmaker.

A fundamental tenet for AIM-Monitoring is that information can be collected once and used many times for many reasons across many programs (e.g.,

recreation, grazing, energy, wildlife, and wild horse and burro management). Further, these data can be easily compared and combined to simultaneously address a wide range of local, regional, and national (i.e., multiscale) management needs. All AIM-Monitoring deployments are intended to achieve five goals determined to be important to land managers, from field to national levels.

The five goals of each AIM-Monitoring deployment include:

1. Determine the status, condition, and trend of priority resources and key ecosystem components and processes.
2. Determine the location, amount, and spatial pattern of priority resources, key ecosystem components and processes, disturbances, and other changes on the landscape.
3. Provide a conceptual understanding of key ecosystem components, processes, and sustainability concepts that should be incorporated into land use plans, National Environmental Policy Act (NEPA) documents, cumulative effects analyses, etc.
4. Generate quantitative and spatial data to address goals 1 and 2 and to contribute to existing land health assessment and evaluation processes at multiple scales of inquiry.
5. Determine if management actions (e.g., land treatments) are moving resources toward desired conditions, as identified by land health standards, planning documents, legal mandates, etc.



Deploying AIM-Monitoring: A Structured Implementation Framework

Using AIM-Monitoring means developing and implementing a monitoring program designed to address resource management questions over the long term (Figure 1). Several aspects of this iterative process distinguish AIM-Monitoring from other monitoring programs. First, after deciding on management objectives, the AIM core indicators and methods are initially considered. If management objectives are not addressed by the core indicators and methods, supplemental ones are then chosen. Second, a statistically valid sampling design is used, which allows scaling up and down to larger and smaller management areas. Third, data are captured, managed, and stored electronically, which decreases human error and ensures data accessibility. Analysis tools will be available through the national geospatial infrastructure where they can contribute to management decisionmaking; determinations of management effectiveness; and local, regional, and national reporting efforts. Finally, field-based AIM-Monitoring data are integrated with remote sensing to learn about the location, amount, and spatial pattern of resources across broad geographic

extents. Collectively, AIM-Monitoring information provides a basis for land managers to adaptively manage resources, improve understanding of the ecosystem, and adjust monitoring efforts as necessary using a well-documented and consistent approach.

What to Measure: Core and Contingent Indicators of Ecosystem Sustainability

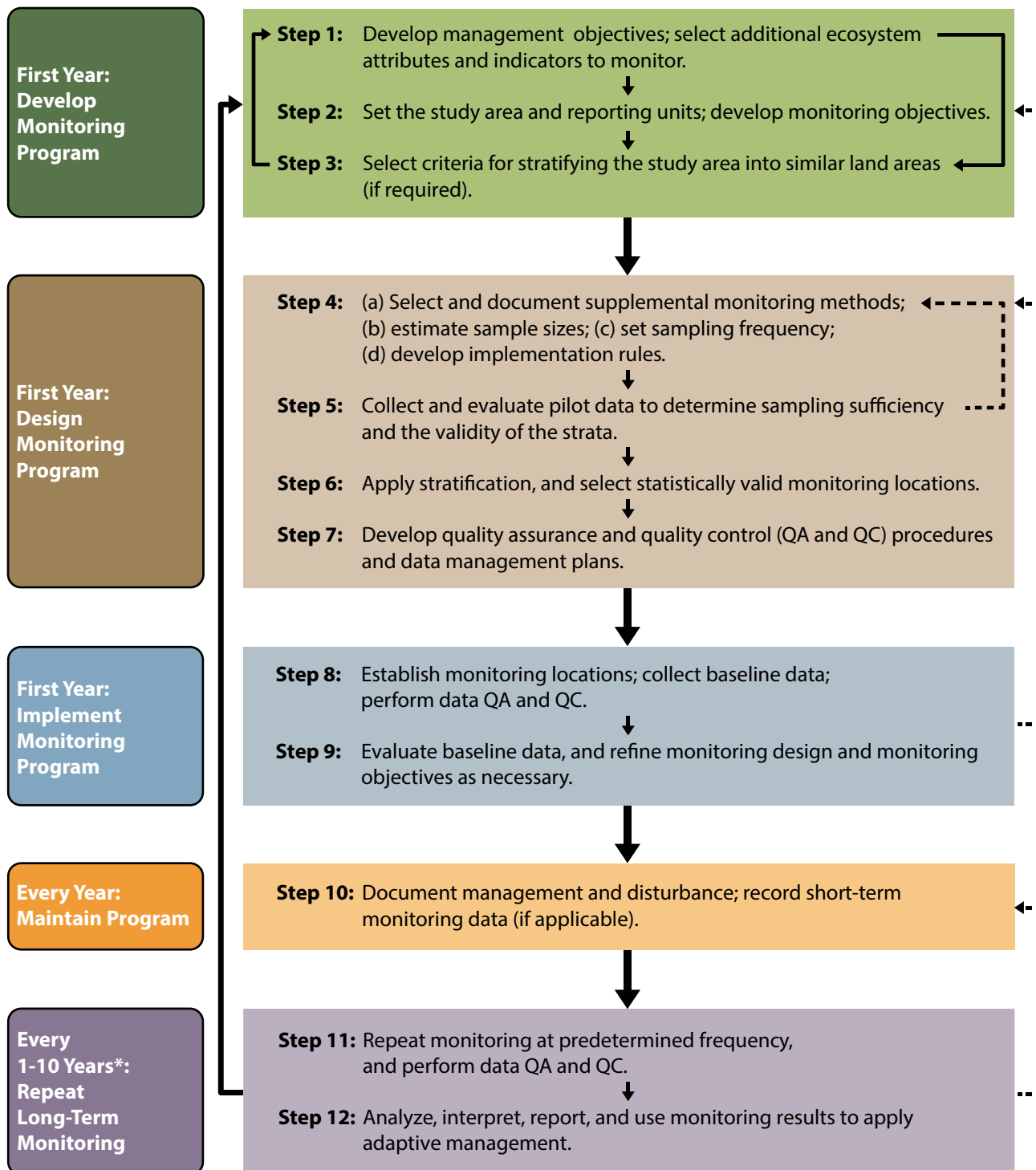
Healthy, sustainable ecosystems support the diverse multiple uses of public lands. AIM-Monitoring has identified broadly applicable (i.e., cross program, cross scale, and cross ecosystem), field-based quantitative monitoring measurements called *core and contingent indicators of terrestrial ecosystem sustainability* (see Table 1). These core terrestrial indicators provide information needed to understand the status, condition, and trend of terrestrial ecosystems managed by the BLM. Efforts are currently underway to add several remote sensing-based core indicators and methods to support mapping and monitoring of landcover and wildlife habitat. Efforts are also underway to select core and contingent indicators of aquatic ecosystem sustainability, which will be introduced in a future BLM technical note.

Table 1. Core and contingent terrestrial indicators and monitoring methods

TYPE	INDICATOR	METHOD	WHERE APPLIED?
Core	Amount of bare ground	Line-point intercept (LPI) for foliar cover, supplemented with plot-level species inventory	All terrestrial ecosystems managed by the BLM
	Vegetation composition		
	Nonnative invasive species		
	Plant species of management concern		
	Vegetation height	Height at selected LPI points	
	Proportion of site in large, intercanopy gaps	Canopy gap intercept	
	* Landcover (habitat) amount, location, and pattern	Remote sensing acquisition and spatial pattern metrics	
	* Aquatic indicators		
Contingent	Soil and site stability		Where necessary
	Soil toxins		
	*Others (e.g., stand density index, wildlife metrics, etc.)		

* In development

The field-based core and contingent terrestrial indicators were selected following a review of BLM monitoring efforts nationwide, interagency input, and a conceptual ecosystem modeling process based on three key attributes of ecosystem sustainability (including biotic integrity, site/soil stability, and hydrologic function) (see Figure 2). The importance of spatial landscape characteristics to ecosystem sustainability has led to the addition of a fourth key attribute, landscape integrity (see Figure 2). These four key attributes, along with their associated terrestrial and aquatic core indicators, will always be measured when an



* The frequency of repeat monitoring will vary by management objective. Typically, treatments (e.g., riparian restoration, postfire rehabilitation) involving relatively rapid responses or where more frequent data may inform adaptive management (e.g., management changes in more mesic environments) require monitoring frequencies of less than once every 5 years. For more long-term management objectives (e.g., grazing management) and in arid environments where responses to management changes are slow to occur, monitoring frequencies of 8-10 years are usually sufficient.

Figure 1. Core monitoring program design, implementation, and integration with management.

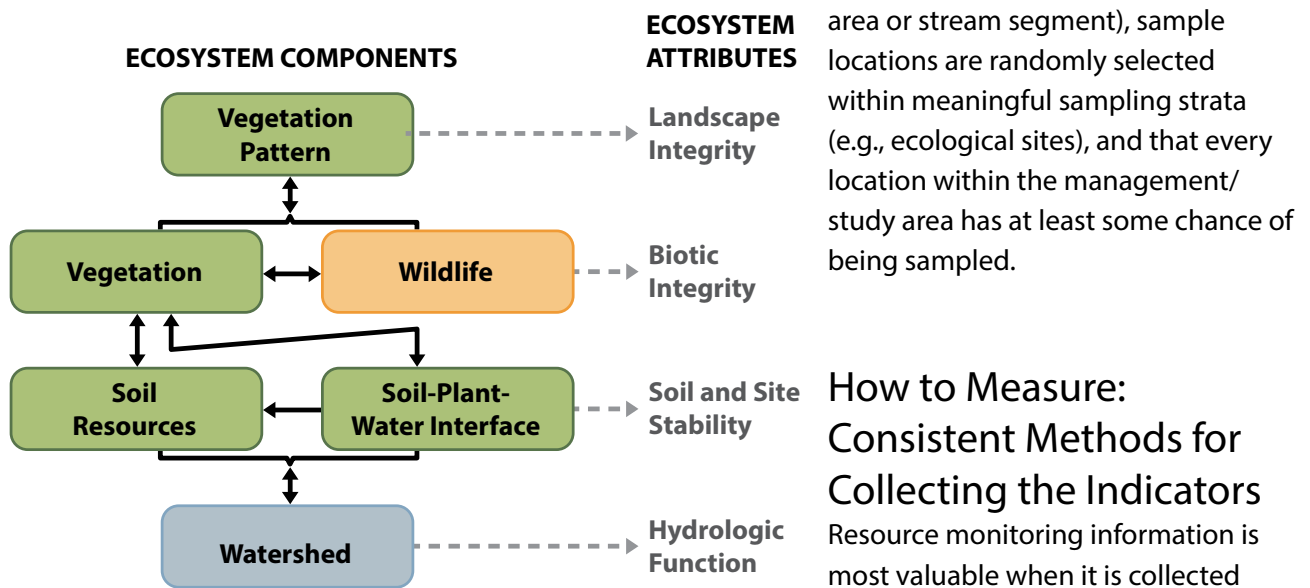


Figure 2. Conceptual ecosystem model depicting functional ecosystem components (boxes), their interactions (arrows), and their relationship to key ecosystem attributes. This figure is modified from Toevs et al. (2011) and inspired by Miller (2005).

AIM-Monitoring design is deployed, regardless of the program or management area where monitoring data are being collected. Lastly, contingent and/or supplemental indicators are measured when necessary to address specific local, regional, or national resource needs or objectives. For example, where juniper encroachment threatens mountain big sagebrush plant communities and associated wildlife habitat (see Figure 3), local managers may decide to measure juniper density as a supplemental indicator.

Where to Measure: A Statistically Valid, Scalable Sampling Design

AIM-Monitoring indicators and methods are designed to be “scalable.” A scalable monitoring design allows information to be collected by local resource managers to meet local management needs and to be combined with data collected elsewhere to address broader, landscape-scale, and national reporting needs. Scalability requires not only consistent indicators and methods, but also a statistically valid sample design. A statistically valid sample design, in the context of AIM-Monitoring, means that the management/study area for monitoring is explicitly defined (e.g., a recreation

area or stream segment), sample locations are randomly selected within meaningful sampling strata (e.g., ecological sites), and that every location within the management/study area has at least some chance of being sampled.

How to Measure: Consistent Methods for Collecting the Indicators

Resource monitoring information is most valuable when it is collected repeatedly in a consistent manner over long periods of time. This is a challenging goal because many resource professionals in diverse locations conduct resource monitoring

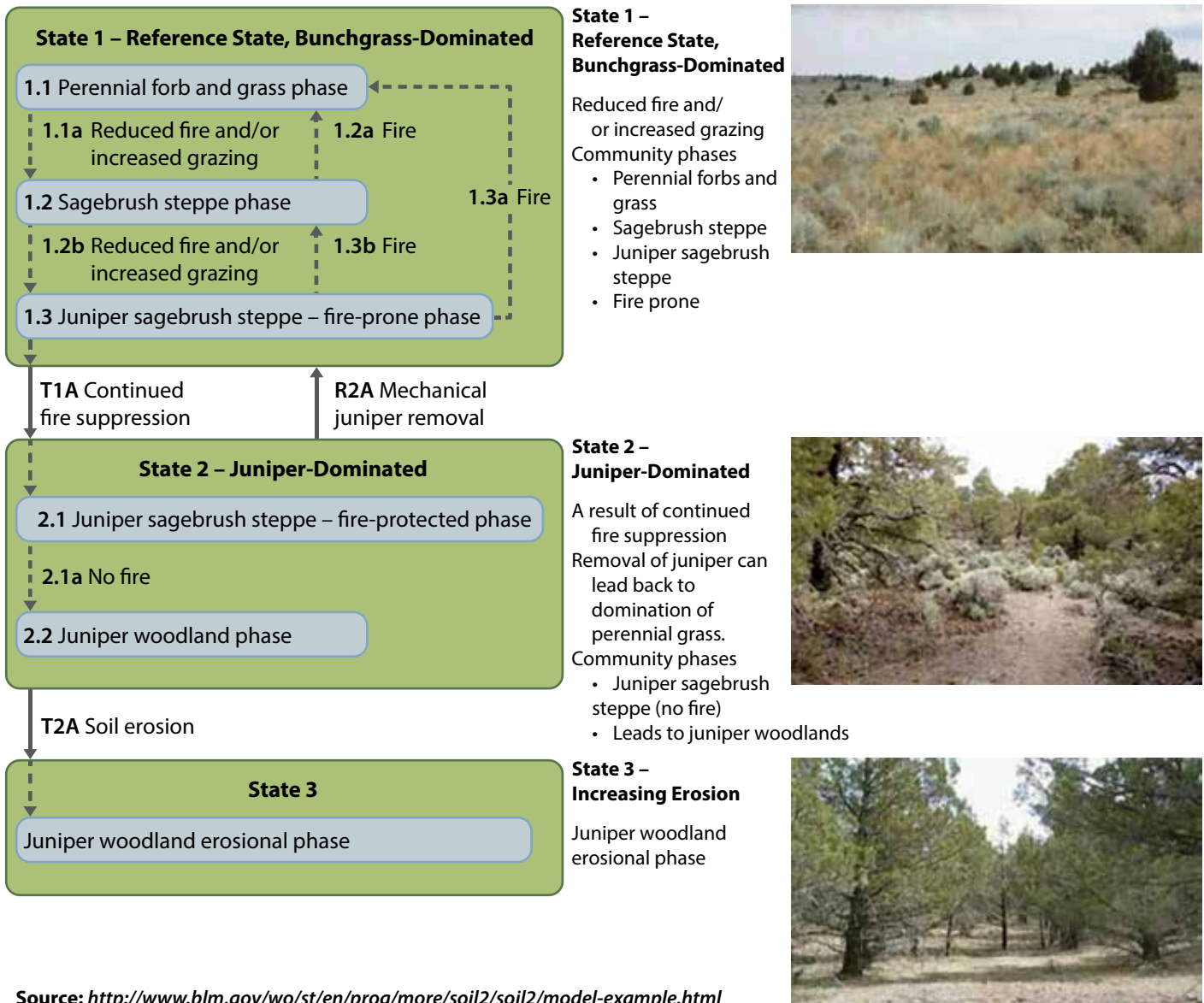
using different methods over different lengths of time. To accomplish long-term consistency and scalability of results, AIM-Monitoring establishes standardized methods for collecting data necessary to derive the core and contingent indicators of ecosystem sustainability. These core and contingent monitoring methods (see Table 1) were selected because they are objective, repeatable with minimal observer bias, easy to implement, well documented, and widely used. Further, these methods reflect the knowledge and experience of scientists, rangeland managers, and ecologists from many different agencies and institutions.

How to Measure: Remote Sensing

Remote sensing refers to the acquisition of resource data collected by any device (e.g., satellites or low-flying aircraft) not in direct contact with the object of interest. The AIM Strategy and AIM-Monitoring emphasize the importance of using remote sensing as a monitoring tool to improve monitoring efficiency. Field-only data provide precise, statistically valid measures of resource status and trend through time. Additionally, field data provide a valuable source of data to “train” and validate remote sensing products. In turn, remote sensing

State-and-Transition Model Example

Transition Diagram for R010XC032OR – SR MOUNTAIN 12–16PZ Ecological Site



Source: <http://www.blm.gov/wo/st/en/prog/more/soil2/soil2/model-example.html>

Figure 3. State - and - transition conceptual model showing ecosystem changes for a type of land in Oregon. Ecosystem states (green boxes) are a set of plant communities (blue boxes) with characteristic ecological functions, such as water flow or nutrient cycling. Transitions (arrows) occur when these ecological functions are disrupted, triggering a shift to a new state with different characteristic plant communities and functions.

data can extend the utility of some field data by providing the location, amount, and spatial pattern of resources and the status, condition, and trend of these resource attributes across broad geographic extents.

By taking advantage of recent advances in remote sensing science, traditional field-only renewable

resource measures (consistent with the AIM core indicators) can be collected using very-high-resolution, 3-dimensional remote sensing imagery. By optimizing the integration of field and remote efforts, field personnel will reduce the number of field samples needed to detect resource changes, focus data collection efforts in areas experiencing high levels of change, and collect data in isolated

locations that are difficult to access. Further, integrating field and remote sensing efforts will reduce costs, improve the BLM's ability to monitor large and diverse landscapes, and detect landscape changes (e.g., disturbance and climate effects) at multiple scales.

Interpreting Measures: Using Monitoring Data to Determine Land Condition and Inform Decisions

Interpreting the status, departure, or rate of change of renewable resources to determine condition requires comparison of data collected via field sampling and/or remote sensing against indicators of ecological attributes for reference conditions. Reference conditions are based on an understanding of site and landscape potential and represent targets for land management.

Ecological site descriptions (ESDs) describe the potential of a site to support different types and amounts of vegetation, determined by factors like soils, climate, and landform. Ecological sites react to factors like disturbance or degradation (historic or current), which can lead to alternative stable plant communities outside the historic potential of the site. Elements of an ESD that are helpful for defining reference conditions and interpreting departure from reference conditions include: state-and-transition conceptual models of plant community changes in response to disturbance or management; descriptions of the range of plant communities that could exist on the site in addition to the potential vegetation; descriptions of anthropogenic and natural disturbances and their potential to cause changes in plant communities;

descriptions of dynamic soil properties (e.g., organic matter content, soil aggregate stability), and soil cover (e.g., bare ground).

ESDs are the basic units for stratifying landscapes for site-level AIM-Monitoring efforts and are also fundamental for most terrestrial upland land health standards and land health evaluations in the BLM. While ESDs are the foundation upon which AIM-Monitoring data are evaluated, efforts are currently underway to determine methods for describing current and reference resource conditions based on land potential at broader scales using a combination of field and remote sensing data.

Putting AIM-Monitoring into Practice: National Landscape Monitoring, Demonstration Areas, and Related Projects

Using the AIM-Monitoring core indicators and methods, in cooperation with the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), the BLM deployed the first year of its Westside Landscape Monitoring Framework (LMF) in 2011. The LMF is a low-intensity sampling effort, collecting approximately 1,000 sample plots per year across BLM-managed public lands. (The LMF is limited to nonforested public lands because the U.S. Forest Service's Forest Inventory and Analysis program provides resource information of all forested lands regardless of ownership or management agency.) The LMF has three primary functions. The first function is to provide regional-scale, statistically valid estimates of terrestrial/upland rangeland resource status, condition, and trend to provide valuable reference conditions for local decisionmaking. The second



function is to provide a framework upon which all locally driven monitoring efforts can be tied, ensuring all BLM-managed lands are covered by a monitoring program. The third function is to provide consistent data necessary to improve the accuracy of national landcover/vegetation mapping, which will increase the utility of this mapping for local vegetation management, planning, and decisionmaking.

The broad applicability and cross-program utility of the AIM-Monitoring core indicators and methods allow for relatively rapid deployment to meet emerging management needs. Such is the case with the BLM's management of greater sage-grouse habitats. Working in conjunction with the NRCS, the BLM is increasing the sampling density of the LMF across the range of the greater sage-grouse to increase our understanding of the status, condition, and trend of these habitats. Importantly, collection of these habitat-specific AIM-Monitoring data is being driven by sage-grouse management questions, but these data are not limited to sage-grouse habitat application in the future. These same data can be used for other wildlife habitat questions and also for recreation, grazing, and climate change effects, to name a few.

Several field-level deployments of AIM-Monitoring for both aquatic and terrestrial ecosystems are underway (see Figure 4). These projects include energy, grazing, sage-grouse, wild horse and burro, postfire restoration, and National Landscape Conservation System (NLCS) management areas in multiple states. AIM-Monitoring is also being implemented on landscape-scale projects in Nevada and Alaska to address specific management needs, to validate that the core indicators are applicable to all ecosystems managed by the BLM, and to ensure that site-level monitoring information can be readily combined to address management questions at broader scales.

Integration of Legacy Monitoring Data

Previously collected (i.e., legacy) monitoring data remain an essential part of the BLM's monitoring framework. To ensure the longevity of these legacy data, BLM personnel are working with statisticians at the USDA Agricultural Research Service and Iowa State University to understand how to best integrate legacy data into AIM-Monitoring-derived products. Further, several pilot efforts are exploring the integration of AIM-Monitoring information with data-rich "key area" and other legacy efforts. Lastly, the BLM is supporting the development of a Land Treatment Digital Library to capture, store, and analyze historical land treatments by all BLM offices in the West. Much work remains in this area, but the BLM remains committed to ensuring the longevity and utility of its legacy monitoring efforts.

Monitoring for Adaptive Management

The BLM will use information derived from AIM-Monitoring to make necessary management adjustments to meet resource objectives described at project, activity plan, resource management plan, and/or national program levels. Reporting at multiple scales will inform decisionmakers on the effectiveness of management actions, opportunities for adaptive management, refinement of conceptual models, and evaluating the monitoring program itself. Adaptive changes will be subject to environmental analysis, land use planning, and public involvement, as appropriate.

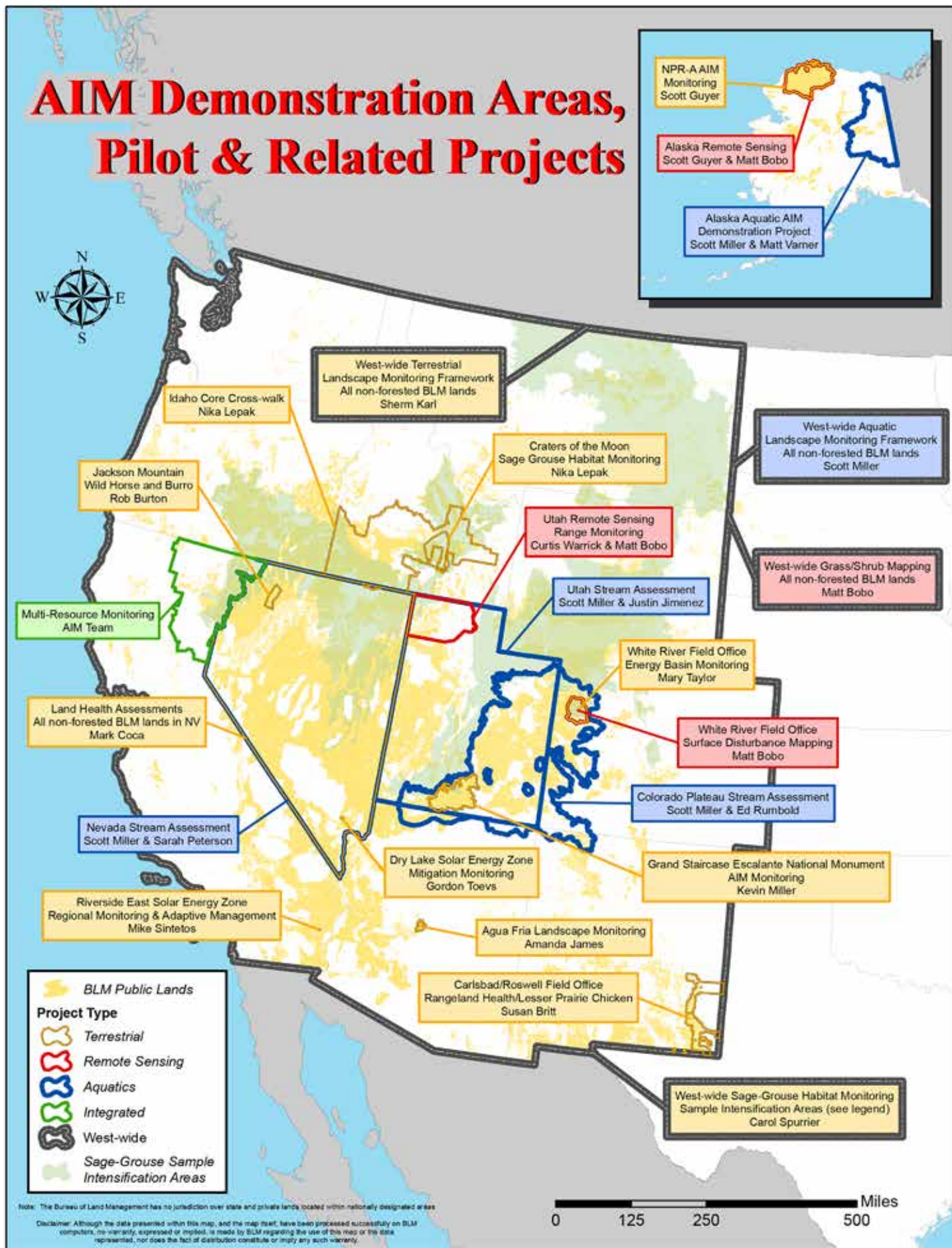


Figure 4. AIM demonstration areas, pilot and related projects.

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