Rangeland Assessment and Monitoring Methods Guide

An interactive tool for selecting methods for assessment and monitoring

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A common concern expressed by land managers and biologists is that they do not know enough about the strengths and weaknesses of different field and remote-sensing methods for rangeland assessment and monitoring. Many are uncertain about which method or combination of methods are most useful for collecting rangeland data to meet their specific monitoring or assessment objectives, or they rely on methods that they have used previously without evaluating whether or not they provide the most appropriate information for their specific objective. Rapid technological developments, limited experience with only a few methods, or the scattered nature of detailed information pertaining to different methods (especially field versus remote-sensing methods) are just some of the reasons for this discomfort. The Rangeland Assessment and Monitoring Methods Guide (Methods Guide for short; available at http://www.rangelandmethods.org) was developed to address these needs and as a resource to synthesize and interpret information on a wide diversity of techniques for collecting data on the condition and trend of rangeland resources.

The Methods Guide is a Web-based resource that provides researchers and managers with information necessary to make informed decisions about which field and remote-sensing method or combination of methods could be most useful and cost-effective for their individual needs. Originally developed by The Nature Conservancy's Idaho Chapter Landscape Toolbox project[i] and Oregon Chapter Sagebrush Cooperative,[ii] the Methods Guide is now being maintained and further developed by the USDA Agricultural Research Service's Jornada Experimental Range. The Methods Guide project benefited from the advice and contributions of over 20 rangeland scientists and managers in both the design and content-creation phases of the project.

[i] Find more on the Landscape Toolbox project at http://www.landscapetoolbox.org.

[ii] Find more on TNC's Oregon Chapter Sagebrush Cooperative at http://sagebrushcooperative.org.

The Methods Guide consists of two parts (Fig. 1) described in greater detail in the following sections. First, it offers a discovery tool that provides information on field and remote-sensing methods relevant to user-defined management questions or objectives. The second part is a wiki devoted to describing rangeland applications of each of the methods. The Methods Guide is intended to be the users' first step in selecting assessment and monitoring protocols by providing information on strengths, limitations, and rangeland applications. This information helps focus further inquiry on a more limited range of techniques.

Scope of the Methods Guide

The reasons for monitoring or assessing rangelands are diverse, but they are invariably tied to management decision making. Accordingly, monitoring and assessment should be tied to specific management goals. Each successful monitoring and assessment program must begin with clearly defined objectives for why monitoring is taking place, what is to be measured, and how the data will be analyzed and used for management purposes.[1] It is easy (and common) to skip these preliminary steps and jump right into selecting methods and designing a monitoring or assessment plan. However, failure to explicitly define objectives and information requirements often leads to data being collected that is either not used (i.e., analyzed and interpreted) or is insufficient to meet management needs.

The Methods Guide was designed to assist in the design of monitoring and assessment programs *after* monitoring objectives have been set. In this context, the Methods Guide is a supportive resource for weighing which techniques could help answer specific management questions. Using the Methods Guide without having a set of clearly articulated objectives runs the risk of "shopping" for attractive methods and may yield inappropriate results.

The Methods Guide was developed to provide information on assessment and monitoring techniques. It was not intended to provide information or recommendations on land management actions.

The Methods Guide includes a diversity of field and remote sensing assessment and monitoring techniques and

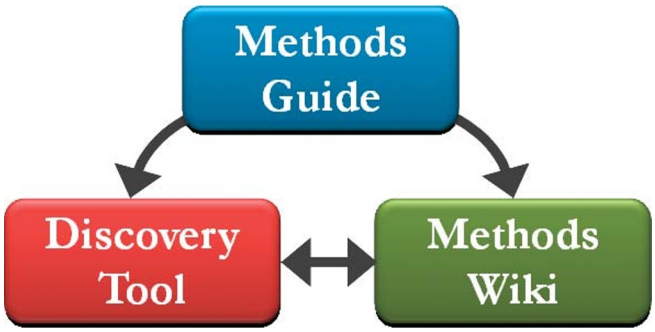


Figure 1. The Methods Guide consists of two interrelated parts: 1) an interactive tool for discovering and comparing methods that could be used to obtain data to answer a specific management question, and 2) a wiki with abstracts discussing the applications, advantages, and limitations of each method.

allows users and external experts to add and describe additional methods. However, the Methods Guide is not a comprehensive listing of assessment and monitoring methods. Likewise, the descriptions and evaluations of the individual methods are not intended to be exhaustive literature reviews but summaries of pertinent literature and illustrative examples.

Presently, the Methods Guide deals with common field and remote sensing techniques for monitoring upland rangelands, including grasslands, shrublands, and savanna ecosystems. While many of the techniques considered in the Methods Guide are applicable to other ecosystem types (e.g., riparian areas, forests), the primary goal was to illustrate their advantages and limitations for upland rangeland systems. Over time the scope of the Methods Guide will increase to formally address monitoring of other ecosystems.

Method Discovery Tool

The first part of the Methods Guide is an interactive, Web-based tool for helping users discover what methods may be useful for their specific assessment and monitoring needs. The purpose of the discovery tool is not to make a specific decision about which technique a manager or biologist should use, but to supply them with a suite of consistent information for a small subset of recommended techniques that could provide them with the kinds of data they need. In this way, the Guide's discovery tool is a decision-making support tool for designing assessment and monitoring programs.

To start the discovery tool, a management question, objective, or keyword entered by the user is searched against an extensive database of existing management topics. This search returns a narrow list of topics related to the user's original entry. The management topics were generated by a panel of rangeland scientists, managers, ecologists, and ranchers in Idaho and Oregon. These topics were designed to clarify the type of information of interest to the user (Table 1). Once a question is selected, the user must choose a date range and scale from a predetermined list. These attributes help focus the remote sensing results to those techniques and data sources relevant to the user's needs.

With this input, the user is then presented with recommended field and remote-sensing methods to collect data to address the original management question or objective (Fig. 2). To make the recommendations, experienced rangeland scientists and managers were enlisted to rate the applicability of each method against each of the standard topics in the Methods Guide. Field and remote-sensing methods were rated separately.

For the field methods, three rating criteria were used: 1) potential for the method to provide accurate estimates of the desired parameter, 2) relative implementation cost or ease of the method, and 3) potential for bias to occur in the estimates. These three criteria are helpful for considering the tradeoffs when deciding which methods are best for the user's application and the feasibility of implementing them. Using these three criteria, experts rated each method on a scale from one to five (i.e., one being the lowest and five being the highest rating). The median expert rating for each criteria is displayed in the Methods Guide.

It is important to note that with field methods, how the sample locations are selected for implementing the method (i.e., sample design) has a tremendous influence on the potential accuracy and bias of estimates derived from a particular method. Presently, the Methods Guide discovery tool does not directly address sample design, but it does include a clear message to the user about the importance of sample design (Fig. 2) and links to resources in the Methods Guide wiki (see next section) that discuss sample design topics in more detail.

Remote sensing methods were rated differently than field methods because they can either provide direct estimates of rangeland parameters (e.g., biomass production) or information that is correlated to the parameter of interest (e.g., greenness indexes). Each of the remote-sensing methods was classified according to the data types in Table 1. Additionally, each remote-sensing method was rated by experts according to its ability to provide information that could be useful in answering the selected management topic (Table 2).

Remote-sensing methods have another unique feature in that they are applied to a specific data set (e.g., satellite or aerial image), and can, in most cases, be applied to any data set that satisfies the minimum requirements of the method. For example, the normalized difference vegetation index (NDVI) is calculated as a ratio of light reflected in the red and near-infrared regions of the electromagnetic spectrum. Many satellite and airborne imaging sensors provide this information, and an NDVI can be calculated for each of these. To accommodate this in the Methods Guide discovery tool, remote-sensing methods are presented in one column and possible data sources (i.e., sensors limited to the scale and date range selected by the user) are presented in a separate column (Fig. 2). Clicking on a method highlights those sensors to which the method can be applied. Conversely, clicking on a sensor highlights the methods applicable to it.

Results within the field methods, remote-sensing methods, and sensor-type sections can be compared using a method

Table 1. Data types considered in the Methods Guide

Data Type	Description	Examples in Methods Guide
Cover	The proportion of ground surface obscured by a vertical projection of the cover class of interest (e.g., living or dead plants or plant parts of one or more species).[1]	Line-point intercept (LPI), canopy-gap intercept
Composition	The proportions of various plant species in relation to the total plant cover of a given area.[1,2]	LPI, dry-weight rank
Density	Numbers of individuals or stems per unit area.[1,2]	Density quadrats, belt transects
Frequency	The ratio between the number of sample units that contain a species and the total number of sample units.[1,2]	Nested frequency
Diversity, richness	The number of different plant species within an area.[1,2]	Plot-level species inventory
Presence/absence	Determination of whether or not a species occurs within an area.[1]	Presence/absence surveys
Classification	Assignment of entities or areas to predefined classes depending on similarity of attributes.[3]	Land-use/land-cover classification
Condition evaluation against a standard	The status of an area when evaluated against values for a predefined set of attributes.	Interpreting indicators of rangeland health[5]
Vertical cover, structure	The height and area occupied by different plants or life forms in a community.[1]	Robel pole, cover board, LPI with height
Population size or condition	The estimated or measured size or condition of a defined population of individuals.[1]	Population estimation
Boundary mapping	Defining and mapping of the boundary of a stand or patch of a species or vegetation community.[1]	Boundary mapping
Production, biomass	The amount of living plant material at any given time (biomass).[1,2] The total quantity of organic material produced in a year (production).[1,2]	Comparative yield, double-sampling
Soil properties	Measures of soil properties like stability, compaction, or infiltration.[6]	Soil aggregate stability test
Utilization	The proportion of current year's forage production that is consumed or destroyed by grazing animals. May refer either to a single species or to a vegetation community.[1,2]	Comparative yield, Cole browse method

comparison tool (Fig. 3). This tool provides a brief side-by-side description and some standard information on the method or sensor.

Throughout the discovery tool results, page icons are available that link each method or sensor directly to its associated Methods Guide wiki page.

Methods Guide Wiki

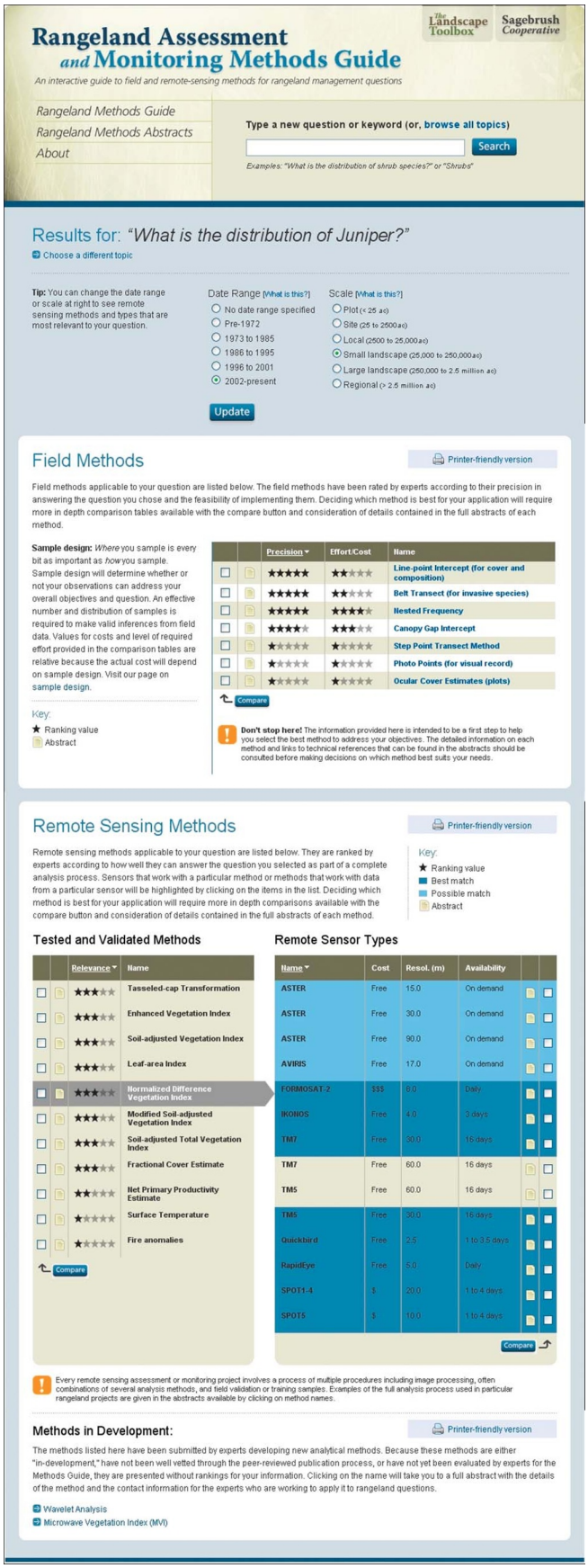
The core of the Methods Guide is a wiki, which features an individual wiki page for each method.[iii] A wiki is a specialized Web site that allows for linked or related Web pages to be easily created and edited by a group of people who share a common purpose. A wiki format was used for the Methods Guide for several reasons. First, the wiki makes it easy and fast to add new methods or topics to the Methods Guide and to correct content. A wide variety of media types can be incorporated directly into the wiki, including pictures or illustrations; graphs and charts; videos; dynamic maps; targeted web, literature, and database searches; discussion areas; and user polls.

The second reason the wiki format is used is that it allows users to compile, and make widely available, information from many different sources (e.g., agency manuals, scientific journals, content databases like Rangelands West[iv] or eXtension[v]) without having to recreate or host them.

[iii] Find the Methods Guide Wiki at http://abstracts.rangelandmethods.org.

[iv] Find more on Rangelands West at http://rangelandswest.org.

[v] Find more on eXtension at http://eXtension.org.



Third, a wiki engages a community of people to keep the content on the site accurate and up to date.

The wiki page for each method, also referred to as an abstract, is an easy-to-understand summary of the method that includes rangeland uses, references, and links to more information (Fig. 4). The wiki page for each method also includes a discussion of the strengths and weakness of each method and similar methods. These abstracts are not intended to be a comprehensive source of information on a method or directions on how to perform a method. As such, the purpose of the Methods Guide is not to replace existing manuals that document methods and protocols, but rather to provide a synthesis of the important points and uses.

The Methods Guide relies on contributions from people who develop, research, and use the many different assessment and monitoring methods. The abstracts in this wiki have been created by rangeland science and management professionals who have generously volunteered their time and expertise. One guiding tenet of the Methods Guide is that many rangeland professionals have experience implementing a host of different assessment and monitoring methods that could be of value to others. To facilitate this exchange of knowledge and information, each wiki page also has a discussion forum where users can post comments relative to the wiki page and offer additional information related to their experiences with a method.

Steps have been taken to ensure that the content in the Methods Guide is as accurate and unbiased as possible. First, each wiki page is written by an expert on that subject. Second, while discussion items can be posted by any user, privileges to edit wiki content must be requested. Third, it is our goal to have all of the wiki pages independently reviewed, with the review status clearly marked at the top of each page.

The flexibility of the wiki also allows for additional content important to assessment and monitoring to be developed and disseminated. With permission, the Methods Guide wiki includes full glossaries from the Society for Range Management[2] and the Canada Center for Remote Sensing.[3] The Methods Guide wiki also includes reviews of several common information sources (e.g., Natural Resource Conservation Service PLANTS database[vi]), formal assessment and monitoring protocols, assessment and monitoring databases (e.g., the Jornada Experimental Range's Database for Inventory, Monitoring, and Assessment;[vii] and the interagency FEAT/FIREMON Integrated database[viii]), and sample design and data analysis tools. Increasingly, the Methods

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Figure 2. Screenshot of sample results from Methods Guide discovery tool.

[vi] Find the NRCS PLANTS database at http://plants.usda.gov.

[vii] Find the Jornada Experimental Range's Database for Inventory, Monitoring and Assessment at http://jornada.nmsu.edu/monit-assess/dima.

[viii] Find the interagency FEAT/FIREMON Integrated database at http://frames.nbii.gov/ffi.

Table 2. Remote sensing methods were rated using the following scale. Remote sensing methods were rated separately for each of the preformatted Methods Guide questions.

Rating	Symbol	Meaning
5	★★★★★	Method provides a direct estimate of an attribute (e.g., cover, biomass)
4	★★★★	Method provides data that are highly correlated with the parameter of interest (e.g., greenness indexes highly correlated to biomass production or cover)
3	★★★	Method can be used in conjunction with another method to estimate an attribute (e.g., greenness indices can be used as an input to classification techniques)
2	★★	Method is only appropriate in limited circumstances
1	N/A	Method is clearly not appropriate for answering the question. Not shown in results.

Guide also hosts reviews and syntheses related to specific assessment and monitoring topics like sample design.[ix]

Limitations and Future Development

While the Methods Guide contains much content that can be helpful for understanding and selecting methods for assessment and monitoring, it continues to be developed and expanded. Currently, the Methods Guide deals primarily with vegetation measurement techniques as they are applied to upland rangeland monitoring. Over time this focus will be expanded to include 1) discussions of how the techniques currently listed in the Methods Guide are or

close window

Field Methods comparison

Topic: *Change in cover of a species*

	Step Point Transect Method	Line-point Intercept (for cover and composition)	Ocular Cover Estimates (plots)
Precision of Estimates	★★★☆☆	★★★★★	★☆☆☆☆
Cost/Effort	★★☆☆☆	★★★☆☆	★★☆☆☆
Potential for Bias	★★★☆☆	★☆☆☆☆	★★★★★
Description	The Step Point Method involves making observations along a walking transect at specified intervals (e.g., number of steps) and using a pin to record cover or "hits" At each interval, the pin is placed at the front of the toe of one foot at the vegetation intercepting the pin and the soil surface where the pin lands is recordedIt measures cover for individual species, total cover, and species composition by cover. Unlike point or line intercept methods, the step-point method does not require using an actual tape measure to mark the transect line. Instead with this method the transect is selected by determining the transect bearing and using a prominent distant landmark, such as a peak, as the transect bearing point.	Line-Point Intercept is a rapid and accurate method for quantifying soil cover, which in addition to vegetation, includes cover by litter, rocks and biological soil crusts. With this method, cover is measured along a linear transect line and is based on the number of "hits" on a target species out of the total number of points measured along that line. It is used when precise, repeatable measurements are required.	Visual estimates of percent plant or soil surface cover, usually by cover classes (e.g., 0-10%, 10-50%). When collecting cover data in plots, Visual or Ocular Cover Estimates are a common approach. Visual plant cover estimates are very subjective but are often used because they are more rapid than other cover methods. Species and their covers are estimated visually as a percent of the area inside a plot. The cover can be defined as an independent percent or placed in a cover class. When using cover classes the observer puts the individual species in a pre-defined cover class, or percentage range, making estimating cover faster since the observer doesn't need to decide if it is a few percentages more or less. Plots can be used to estimate canopy, foliar, or ground cover, however they don't work well for basal cover. Plot sizes vary, ranging from very small quadrats to belt transects, depending on the monitoring objectives and sample design.
Type	Quantitative	Quantitative	Quantitative
BLM Method	Unknown	Approved	Approved
Forest Service Method	Approved	Approved	Approved
NRCS Method	Approved	Protocol	Approved
Data	Cover	Cover, Composition	Cover, Density/Frequency

Figure 3. Comparison of field methods selected from the results shown in Figure 2.

[ix] For example, see http://abstracts.rangelandmethods.org/doku.php/general_design_topics.

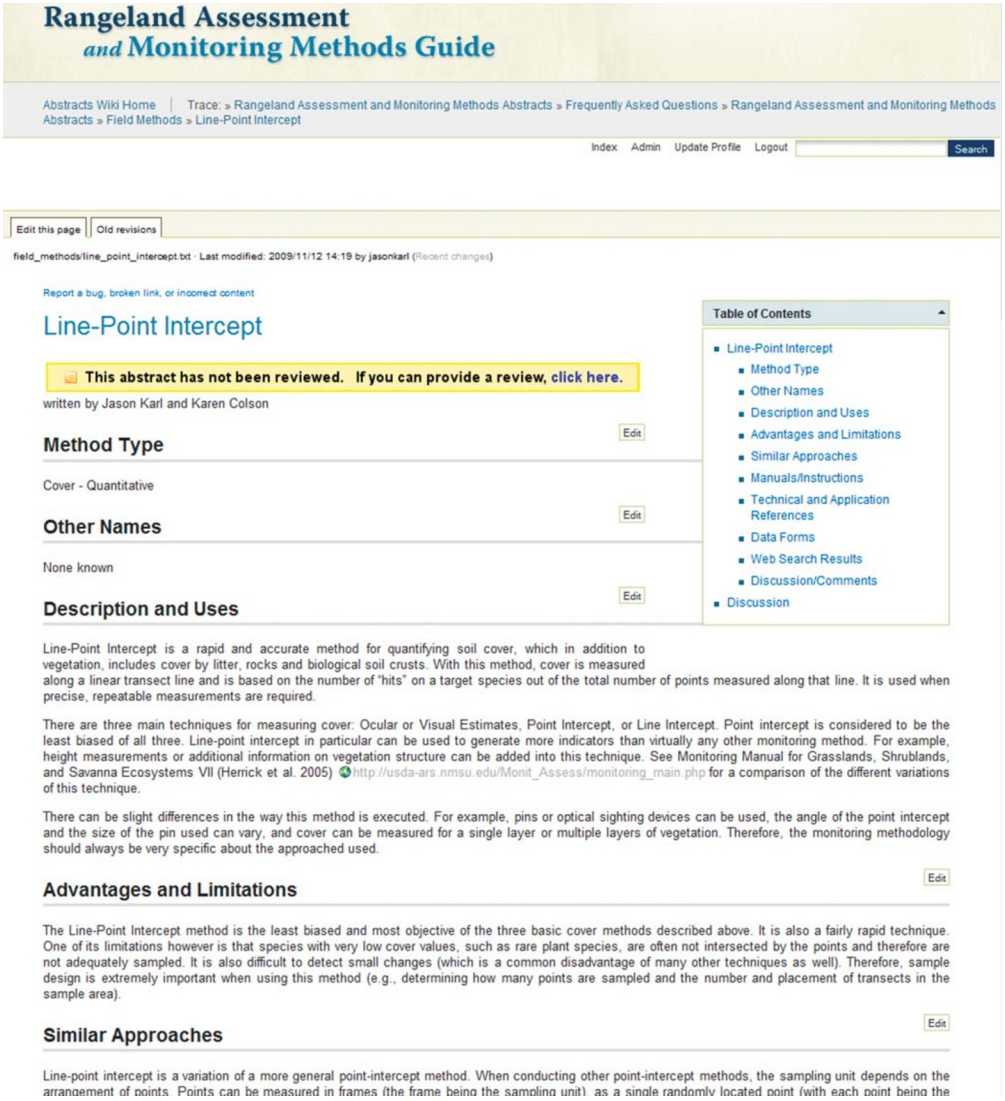

Figure 4. Screenshot of the Methods Guide wiki page for the line-point-intercept field technique for estimating percent cover and composition.

could be used in other ecosystems and 2) additional methods that are commonly used for monitoring other ecosystem types (e.g., riparian areas, forests) or attributes (e.g., soil properties). Also, the discovery tool presently considers only field and remote-sensing methods. Our goal is to expand the scope of the discovery tool to include additional topics that are already being addressed in the wiki-like sample design, protocols (i.e., specific collections of methods), and databases.

In its current form, the Methods Guide provides information on which techniques may be useful for addressing a specific and well-defined management information need. It does not address what should be done with monitoring data once collected (i.e., how should it be analyzed and interpreted). While academic and government researchers have made strides in providing accessible statistical tools to make it easier to analyze and interpret monitoring data, clear and easy-to-understand guidance for how and when to use these tools has lagged behind. A long-term development goal for the Methods Guide is to begin to synthesize existing information on analysis and interpretation of monitoring data and make it available to rangeland management professionals.

One perennial challenge with a site like the Methods Guide is keeping the content current as new techniques evolve and as additional information is generated for each method. While this has traditionally involved investment of researchers and students to search out and synthesize new information, emerging Internet search technologies facilitate this process. By partnering with sites like Rangelands West or journal Web sites that can compile relevant information via structured searches, new content can be more readily identified and added to existing entries in the Methods Guide. Opportunities also exist to engage faculty and students in university rangeland programs to contribute their experiences and results of method evaluations and to use the Methods Guide as a way to promote novel assessment and monitoring techniques.

The remote-sensing results of the discovery tool currently present a somewhat simplistic view of how remote sensing is implemented in rangeland assessment and monitoring. Almost all remote sensing applications require a coordinated application of many different data sources and methods to achieve good estimates of rangeland attributes. In the future, the remote-sensing results section of the discovery tool will be redesigned around the concept of these workflows, and these workflows will be illustrated with examples from published research and monitoring programs.

Conclusions

Designing assessment and monitoring programs is a complex task that is part of a larger, even more complex, management process. To work at its best, this management process requires 1) an understanding of the processes involved in maintaining or changing ecosystems over time and 2) a framework for organizing, collecting, and applying all of the available relevant information for a management objective.[4] Presently, many of the pieces exist to create such a knowledge system to support rangeland management. However, because these pieces were developed separately, they do not function together to the level needed to support effective management. With the increasing emphasis on developing and supporting data exchange between web-based tools, isolation of these pieces will decrease.

The value of the Methods Guide is that it brings together and interprets information from a wide array of sources, including peer-reviewed research, agency manuals and reports, comparison studies, expert experience and advice, and anecdotal information. The Methods Guide also helps users narrow down this vast amount of information so that they can make more informed decisions about which method or combination of methods best fits their individual assessment and monitoring information needs.

Over time, the Methods Guide will evolve along with many other ongoing efforts (e.g., ecological site descriptions, Rangelands West, eXtension) into a platform for linking to and integrating, in a comprehensive way, many of the different assessment and monitoring methods, analysis tools, and land management techniques with understanding of ecosystem functioning to create a more comprehensive knowledge system to support rangeland management.

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