WORKKSHOP T15

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NEW TOOLS FOR RANGELAND AND PASTURE MONITORING

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ABSTRACT

This paper describes a set of tools that help land managers easily collect, analyze, interpret and store data that are most relevant to their management objectives. The toolbox includes vegetation and soil methods that are nationally applied by one or more federal agencies, together with additional methods that are appropriate for rangelands, pasturelands and can be applied to annual cropping systems. The methods can be applied to small and large farms and ranches, and to large watersheds and are relevant to both production and conservation objectives. The tools include a two-volume manual, a set of Excel spreadsheets that automatically calculate indicators for a single plot, and a computer database/field data entry program that automatically generates and compares indicators for multiple plots. A 40-page "Quick Start" volume provides step-by-step instructions for completing five basic monitoring methods along with rapid semi-quantitative alternative methods. Volume II includes additional methods, a monitoring system design guide, and information to help interpret results and apply them to different management objectives. The Excel Spreadsheets are identical to the paper data forms printed in the manuals. The Access database/field data entry system includes all of the data entry forms from the manual, together with data forms for other commonly used methods. When applied at the farm or ranch level, no database experience is required. The user simply enters the data as they would on paper, and indicators are automatically generated for each plot. Data can be entered directly in the field using a "Tablet" computer, or in the office on a standard personal computer. Both the monitoring manual and the database/field data entry system were designed as "toolboxes." Different sets of tools are selected for different jobs. The paper describes how to apply the methods to livestock production, wildlife habitat management, control of invasive species and other objectives. It ends with a brief overview of new monitoring tools the Jornada is developing, including Unmanned Aerial Vehicles (UAV's) that, guided by GPS, fly autonomously, and collect high resolution photographs across large areas. The manuals, data forms and database can be downloaded from http://usda-ars.nmsu.edu/monit_assess/monitoring.php. Printed copies of the manuals are available from online booksellers.

INTRODUCTION — THE NEED FOR A MONITORING TOOLBOX

Each piece of land is unique and each land manager has different objectives. All managers have limited time available for monitoring. There are many monitoring guides available, but each has one or more of the following limitations:

- Vegetation methods limited to upland or riparian systems.
- Soil methods not included or too complex.
- Insufficient detail to consistently repeat the methods.
- Lack guidance on how to select methods, and how to decide how many measurements are necessary.
- Lack system for calculating indicators.
- Lack system for interpreting indicators.
- Limited to a single management objective and fail to reflect overall land health.
- Too inflexible to be applied to different objectives.
- Too time-consuming.
- Not scientifically-based.

Ranchers, farmers, consultants, and state and federal agencies identified these limitations in the 1990's. In response, the USDA Agricultural Research Service (ARS), in cooperation with a large number of individuals and organizations, developed the "Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems." The manual and the optional computer software are based on recent and historic research. They are designed to help managers select the most appropriate monitoring tools and apply them as cost-effectively as possible.

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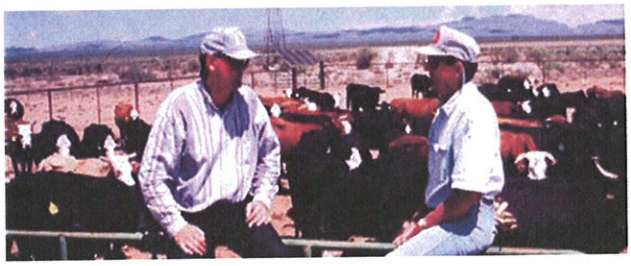
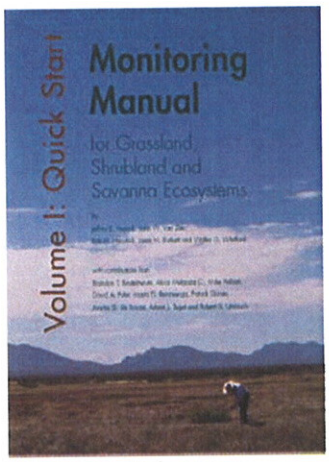


TOOLBOX

The toolbox includes four types of tools: a "Quick Start" monitoring manual which can be used independently, a supplementary monitoring manual with more detailed information, spreadsheet data forms and a database.

1. Monitoring Manual Volume I: Quick Start

A 40-page "Quick Start" manual describes five basic methods that generate indicators relevant to most land management objectives: (1) photographs, (2) vegetation cover and composition (line-point intercept), (3) area covered by large bare patches (gap intercept), (4) soil aggregate stability (soil stability kit), and (5) invasive species density (belt transects). Data forms for the last four facilitate rapid indicator calculations in the field. Methods can be used alone or in any combination, depending on objectives (Havstad and Herrick, 2003; Herrick et al., 2005). Each method includes paper data forms, and there is a separate section for recording short-term management records (stocking rates, residual cover, off-road vehicle use, etc.).

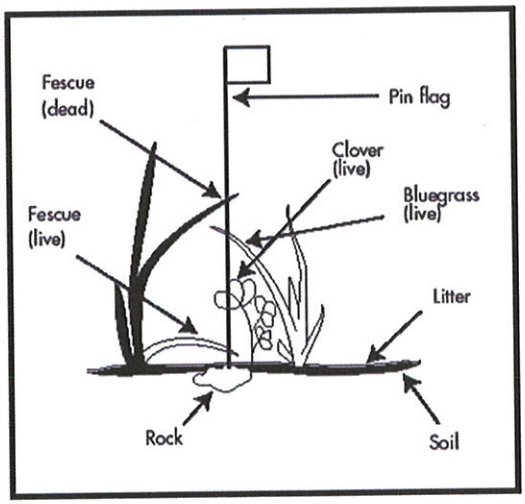


Photographs

Photographs are included in nearly every monitoring program. When used alone, they provide qualitative documentation of general changes. They can also be used to help support and illustrate quantitative data.

Vegetation Cover and Composition (Line-Point Intercept)

Vegetation cover (canopy and basal) and composition (dominant species) is one of the most valuable long-term indicators available. The simplest and most reliable method to monitor vegetation cover and composition (including bare ground) is with line-point intercept. Step-point can be substituted, but for greater reliability, we recommend using a pin instead of the tip of the boot. For infrequently encountered species (e.g., to detect invasive species) use the belt transect method below, or the species richness method in Volume II.



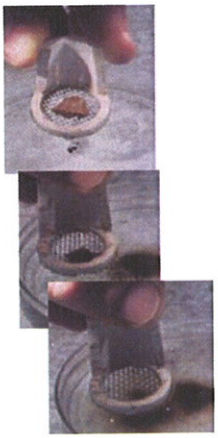
Large Bare Patches (Gap Intercept)

The appearance of large bare patches between plant canopies or bases is one of the most important signs of degradation in many pastures and rangelands. While the percentage of bare ground is important, erosion is most likely to occur (and invasives are often most likely to establish) in large patches. Research at the Jornada (Okin et al., 2006) has shown that the size of these patches is correlated with soil erosion. If there is no time to measure patches on a transect, an easy alternative is to count the number of paces (out of 100) where your boot lands entirely within a patch (Step-gap).

Soil Aggregate Stability (Soil Stability Kit)

Soil organic matter is the "glue" that holds soil together and helps keep it from washing away. It also keeps the pores that conduct

water into the soil from sealing shut. Organic matter is often too expensive to measure and requires laboratory analyses, but the soil stability method only requires 10–20 minutes to test 18 samples in the field. This method reflects the susceptibility of soil to erosion and physical crusting (Herrick et al., 2001; Pierson et al., 1994). Because these relatively large soil aggregates depend on the input of new soil organic matter every year (soil microbes are always eating last year's glue), it can also be a good indicator of soil organic matter cycling.

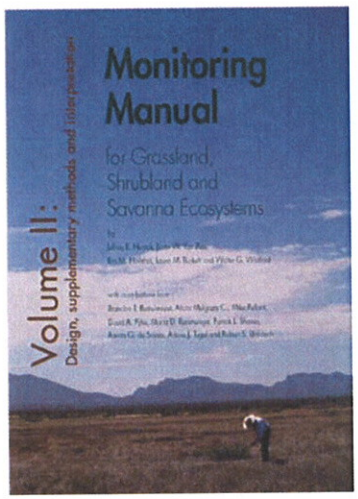


Invasive Species Density (Belt Transect)

Invasive species are one of the greatest threats in many regions. This test provides a simple, rapid, quantitative way to measure their spread. Simply walk along a measuring tape or pace a known distance and count plants within a specified distance. A pole held perpendicular to the transect can be used to determine if a plant is in or out of the plot. For example, a 100-foot transect, 4 feet wide (2 feet on each side) will create a 400 square foot plot, or just under 1/100th of an acre (43,560 square feet).

2. Monitoring Manual Volume II: Design, Supplementary Methods and Interpretation

The second volume includes sections on monitoring program design, supplementary methods, and indicator calculation and interpretation. It also includes a special topics section to help select and interpret indicators for specific management objectives.

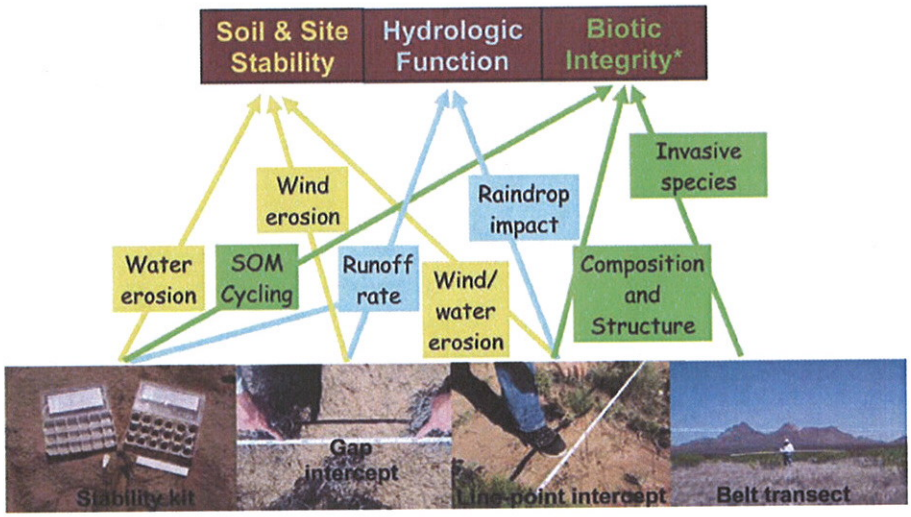


Monitoring Program Design

The six-step process begins with identifying objectives and ends with plot establishment and data collection. We recommend completing a rapid assessment as part of this process (e.g., Pellant et al., 2005) to help identify key indicators. The qualitative indicators used in this process can also be used to help interpret quantitative indicators. An additional four steps describe how to apply the monitoring system to guide management.

Supplementary Methods

The supplementary methods are those that are likely to be used in fewer monitoring programs because they are designed for more



specific objectives. Some methods are also more time-consuming or more complex than those included in Quick Start. They include methods for monitoring soils and riparian zones. This section will be expanded in future editions.

Indicator Calculation and Interpretation

Indicator calculation instructions are included with each method, and indicators are automatically calculated in the Excel and Access tools described below. The primary goal of this section is to help users interpret the indicators.

Special Topics

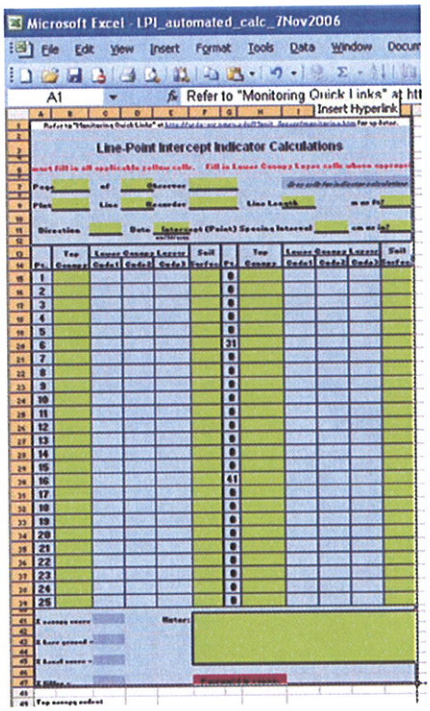
The special topics section provides guidance on how to select and interpret indicators for wildlife habitat, livestock production, fire, invasive species, soil carbon, riparian area management and off-highway vehicle (OHV) use. It also includes very brief introductions to state and transition models and remote sensing. There are a number of additional references that provide more extensive information on the application of state and transition models to management (e.g., Bestelmeyer et al., 2003; Stringham et al., 2003; Bestelmeyer et al., 2004; Briske et al., 2005).

Appendices

The appendices include estimates of the number of measurements or transects required for different objectives, and instructions for constructing monitoring tools described in Volume II.

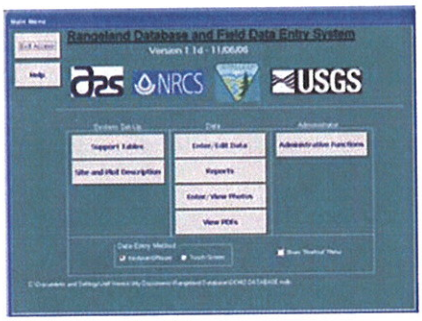
3. Spreadsheet Data Forms

The spreadsheet data forms are virtually identical to the paper data forms in the manual. The difference is that key indicators are automatically calculated at the bottom of each form. They can be downloaded from http://usda-ars.nmsu.edu/monit_assess/monitoring.php.



4. Database and Field Data Entry System

Databases are becoming increasingly important in managing large datasets. The recently developed Rangeland Database and Field Data Entry System is a Microsoft Access database that can be easily used without Access knowledge. The database was developed to increase data entry speed and precision in both field and office. Data can be rapidly entered in the field using a Tablet PC (touch-screen entry) or in the office on a standard computer (keyboard entry) with user-specified choice lists. The database can be easily customized to suit the user's needs.



Features

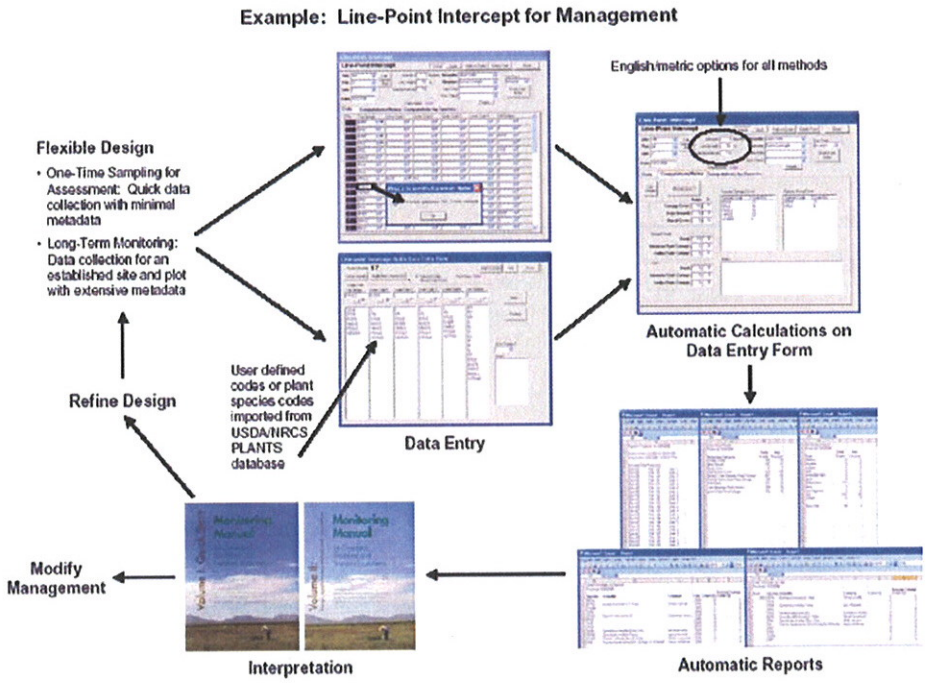
The database has the following features:

- Simple interface (an Access database that doesn't require knowledge of Access to use)
- Tablet PC (touchscreen) and keyboard modes
- Flexible — adapts to most monitoring applications
- Drop-down choice lists increase data entry speed and precision
- Automated indicator calculations and reports, and ability to create user-defined queries
- Import data from Excel into database
- Automated plant species list downloads from USDA/NRCS PLANTS database
- Three levels of user-defined security to increase data entry consistency

Vegetation	**Soils**
Dry Weight Rank	Single-Ring Infiltrometer
Gap Intercept	Soil Compaction (Impact Penetrometer)
Line-Point Intercept	Soil Stability
Ocular Cover Estimate	
Plant Density/Belt Transect	
Plant Production	**Riparian**
Species Richness	Channel/Gully Profile
Tree Inventory (includes Density)	**Qualitative Assessment**
Vegetation Structure (Cover Pole/Board)	Rangeland Health

Current Methods

The database includes all methods described in both volumes of the monitoring manual. It also includes a number of other commonly used methods and links to digital photos.



Example

The example above illustrates some of the features of the database and shows how it can be applied to management.

NEW MONITORING TOOLS

Several Agricultural Research Service units are involved in the development of new monitoring tools. The Jornada Experimental Range is working on a number of new tools relevant to pastures and rangelands. These include using laser-induced fluorescence to monitor diet composition and forage quality (Danielson et al., 2006), satellite and modeling-based methods for predicting snowmelt runoff (and therefore water availability for summer irrigation and other requirements; Rango et al., 2006), and integrated ground-based and satellite and/or aerial photography measurements for rangeland assessment and monitoring (Laliberte et al., 2004; Laliberte et al., In Press).

Here, we briefly outline our work on the use of Unmanned Aerial Vehicles (UAV's) that, guided by GPS, fly autonomously, and collect high resolution photographs across large areas. UAV's have the potential to provide land managers with the ability to collect high-resolution (approximately 5 cm or 2 inches from an altitude of 150 m) images at a relatively low cost (Rango et al., In Press).

Simple versions consisting of a model airplane modified to accommodate a digital camera and GPS unit can be constructed using off-the-shelf materials. More sophisticated versions include instruments that help keep the camera level, and software that keeps track of speed, orientation and other variables needed to precisely locate the areas to be photographed.

Research issues regarding the implementation of UAV's include the development of: (a) rapid, simple systems to join multiple photos together to create a single image covering a relatively large area, (b) sampling strategies to cover even larger areas, without acquiring a photograph of every point on the ground, and (c) standardized systems to integrate UAV photo data with ground-based measurements. We are also testing the accuracy of indicators generated from these photos against ground-based measurements.

We are also continuing to conduct research on monitoring program design. Careful consideration of monitoring program design can save thousands of dollars in monitoring costs for individual monitoring programs, and potentially millions at the national level. For example, a series of analyses of the USDA-NRI program completed by ARS and NRCS scientists resulted in a nearly 50% reduction in field time by reducing the number of measurements at each plot (Herrick et al., 2006).

CONCLUSIONS

New monitoring and assessment tools are being developed every year by a number of individuals and organizations. We will continue to work on the development of new tools in collaboration with other ARS units, universities, state and federal agencies and the private sector. Our website is constantly updated and we welcome inquiries and suggestions.

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