Sampling dynamic soil properties for soil surveys: Lessons learned

Arlene J. Tugel
USDA-NRCS Soil Quality Institute
MSC 3JER NMSU, Box 30003
Las Cruces, NM 88003-0003
505-646-2660
atugel@nmsu.edu

Lynn Loomis, USDA-NRCS, Marfa, TX
Susan Andrews, USDA-NRCS Soil Quality Institute, Ames, IA
Judith Dyess, USFS, Albuquerque, NM, (formerly USDA-NRCS, Marfa, TX
Jeffery E. Herrick, USDA-ARS Jornada Experimental Range, Las Cruces, NM
George Peacock, USDA-NRCS, Grazing Lands Technology Institute, Fort Worth, TX
Pete Biggam, USDI-NPS, Denver, CO

ABSTRACT

Today's land managers and policy makers need information about how soils change to compare alternatives and make decisions for economically and environmentally sound resource management. Soil change information can be used to answer questions about current soil condition and make predictions of future conditions. However, soil surveys do not provide information about historical or expected dynamics of soil properties that change in response to management and disturbances. Data collection procedures tested for the Soil Survey of Big Bend National Park, TX included: bulk density, salinity, pH, soil surface stability, infiltration, impact penetrometer, modified singleton-blade, organic and inorganic carbon, canopy cover and canopy gap. Soil surface stability, bulk density soil organic and inorganic carbon and electrical conductivity differed significantly among ecological states. However, differences for some properties were probably not functionally significant. State and transition models for ecological sites were used to select sampling sites and illustrate relationships among data. The experiences gained will be used to improve methods, sampling design, and field efficiency. Research needs were identified. State-dependent dynamic soil property values will add value to soil surveys, enhance information on soil-vegetation dynamics within ecological site descriptions, and increase our knowledge of soil change.

1. INTRODUCTION

Data for soil properties that change in response to management (dynamic soil properties) was requested by Big Bend National Park, TX for planning, restoration and monitoring activities. Two sampling trips to collect dynamic soil property data were conducted: April 22-24, 2003 and April 5-9, 2004. These were the first rangeland soil survey field trials of new procedures for dynamic soil properties. The draft procedures were developed by the Soil Quality Institute of the USDA-Natural Resources Conservation Service and the Jornada Experimental Range of the USDA-Agricultural Research Service. Objectives for this project included: 1) Test sampling design based on state and transition models, 2) Integrate soil and vegetation sampling using field methods, 3) Determine what can be done on a soil survey project and how much time is required, 4) Meet National Park soil data needs for restoration and management. Feedback from this field trial will enhance the development of new technologies for use on other soil surveys.

2. METHODS

Sampling was completed for two different states of the state and transition model for the Silty Desert Shrub (42) ecological site (proposed) on the Chalkdraw (T) series. Chalkdraw is a fine-silty, mixed, superactive, hyperthermic Typic Haplocambid. Plant communities observed included mesquite, creostebush and tobosa grass. Three 50 m transects for each state were used to organize all sampling. Methods adapted from Herrick and others (in prep.) and USDA-NRCS (1998) included 1) line-point intercept for plant/litter cover and soil surface features (biological crusts, rock fragments, physical crust, bare soil, plant bases), 2) basal and canopy gap, 3) soil surface stability, 4) infiltration, 5) impact penetrometer, 6) modified singleton-blade, and 7) samples of 0-5 cm for particle size, soil salinity, pH and soil carbon. Eighteen soil measurements or samples were collected for each state.

3. RESULTS AND DISCUSSION

3.1 Soil and Vegetation Measures

Sampling procedures that integrate soil and vegetation properties and topography were used in order to describe the spatial patterns and variability of soil properties in relation to plant distribution. These relationships are important for understanding and characterizing soil function and ecological site descriptions. However, one of the states sampled was 99% "no canopy" and did not include any grass. Consequently, data could be stratified by canopy/no canopy, but not by canopy type (grass, shrub). Although some properties (e.g. soil surface stability, bulk density, soil organic and inorganic carbon, and electrical conductivity) differed significantly among ecological states, they may not have been functionally significant. Infiltration had the highest variability and pH and inorganic carbon, the lowest. Properties with greater variance require larger number of samples for statistically valid results.

3.2 Workload and staffing

Participating field soil scientists received training in new methods. A high level of proficiency was achieved after one or two days of using the methods. Time to complete the full suite of tests in 2003 was 3 hours for 6 people (5 soil scientists and 1 range conservationist). In 2004, 3 people completed infiltration, soil surface stability, impact-penetrometer and modified singleton-blade in 7 hours for a total of 20 staff hours.

4. CONCLUSIONS

Understanding user needs related to soil change is a prerequisite for developing soil survey enhancements that include dynamic soil properties. Combining sampling procedures for vegetation and soil increases the usefulness of the data. Teaming up with range specialists is essential for site selection and data interpretation, and helpful although not essential, for data collection. Experienced soil scientists could train technicians to collect the data once sample sites have been selected.

These methods are most suited to document locations such as typical pedons, ecological reference areas and benchmark soils. Simpler methods are needed for day-to-day mapping. Although it can take up to an hour to set up 3 transect lines in dense shrub plant communities, the transect design provides for orderly sample collection. This eliminates sample bias, speeds data collection, and protects the individual sample sites from disturbance by the data collectors. However, other sampling designs such as quadrats should be tested for their performance in soil map unit components with patchy vegetation (such as this one).

Workload estimates in the future will depend upon the methods included and the required number of replicates. The numbers of replicates collected in this project may have been greater than needed for some soils and fewer for others. An analysis of variance based on this project and other studies will help determine the required minimum number for future sampling. Every attempt will be made to maximize efficiency.

Research is needed to support the inclusion of dynamic soil property data in soil survey. Research needs include: 1) Test space for time sampling methods as related to state and transition models, 2) Identify functionally important properties to measure, their minimum sample requirements, and critical functional levels for each property, 3) Couple near-surface data with whole pedon data for interpretive purposes, 4) Develop soil change interpretations.

Soil survey enhancements for dynamic soil properties and soil function will add value to soil surveys, enhance information on soil-vegetation dynamics within ecological site descriptions, and increase our knowledge of soil change. Adding information about dynamic soil properties and soil change meets information needs of resource managers for a variety of management activities and goals. These include assessment and monitoring, short and long-term productivity, economics, sustainability, and environmental quality.

5. REFERENCES

Herrick, J.E., J.W. Van Zee, K.M. Havstad and W.G. Whitford. *in prep.* Monitoring manual for grassland, shrubland and savanna ecosystems. USDA-ARS Jornada Experimental Range.

USDA-NRCS. 1998. Soil quality kit guide. Available on-line with updates at http://soils.usda.gov/sqi/