# Pilot Studies for Dynamic Soil Properties: Lessons Learned for Soil Survey

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## Introduction

Soil survey data collection procedures to describe management effects on soil are under development. Four pilot studies were conducted by National Cooperative Soil Survey cooperators (NRCS, NPS, FS, ARS, BLM, U. Idaho) to help craft, test, and refine sampling protocols. State and transition models were used to select plant communities to be sampled (Stringham et al., 2003). A summary of lessons learned from these studies is presented. Field methods, sampling efficiency, and data summary will be discussed. Dynamic soil property data will be used to interpret soil functions for resource planning and management and to support Ecological Site Description development. See also poster 1523.

## Big Bend National Park (TX, 2002-2004)

### Technology Development Objectives

1.Test integrated soil and vegetation data collection procedures and evaluate field experiences. Primary question: Is it feasible to add data collection procedures to the Soil Survey Program in order to quantify dynamic soil properties for interpretations within ecological sites?

### Project Objective and Sampling Design

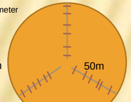
**Are the soil surface properties different within two plots each representing a different state of tobosa grassland on the same soil?**

Patterned shrub savanna community

Sparsely vegetated community

Sampling design – The extent of sampling was limited to one polygon containing Chalkdraw silty clay loam (Fine-silty, mixed, superactive, hyperthermic Typic Haplocambids). Data collection was organized within 55 m dia plots. One plot was located in the patterned shrub savannah community and 1 in the sparsely vegetated community.

**Replicate plots:** 1 per plant community
**Soil subsample locations:** 18 per plot
**Sampling depth:** 0-5 cm
**Soil properties:** particle size, OC, CaCO3, bulk density, EC, pH
**Field measurements:** soil aggregate stability, infiltration, impact penetrometer
**Vegetation:** Canopy and basal gap, line point for cover and species




55m dia plot includes 3 50m transects and 6 soil sample locations per transect.

### Lessons Learned

- Sampling procedures were suitable for field soil scientists and range management specialists although streamlined methods are needed for day to day field work.
- Running tests for nine subsamples at a plot was much more manageable and gave a greater sense of accomplishment than 18.
- Differences in soil surface stability, OC, and possibly salinity suggest they may be suitable soil quality indicators.
- Because the study lacked replicates for each plant community, we cannot say the data represents the plant community throughout all polygons of the targeted map unit component phase.

**Acknowledgments**
Sampling was completed by staff of the NRCS in Texas, Utah, Missouri, and Idaho, the USDA-FS Rocky Mountain Research Station, Idaho, and Missouri Department of Natural Resources. We are grateful for the assistance provided by many individuals and organizations: Big Bend, Arches and Canyonlands National Parks staff; Dr. Jeff Herrick and Dr. Brandon Bestelmeyer, ARS Jornada Experimental Range, NM; Dr. Jayne Belnap, USGS, UT; Dr. April Ulery and Judy Ward, New Mexico State University; University of Missouri Soil Characterization Laboratory; Dr. Paul McDaniel and Anita Falen, University of Idaho; Dr. Mark Kimsey, Intermountain Forest Tree Nutrition Cooperative.

## Arches National Park (UT, 2005-2006)

### Technology Development Objectives

1. Test the comparison study approach (Pickett, 1989; Richter and Markewitz, 2001) for integrated soil and vegetation data collection on rangeland.
2. Test specific improvements over the Big Bend Pilot, as follows:
   a. Sample randomly located and replicated plots.
   b. Stratify soil sampling by canopy type.
   c. Sample multiple soil horizons.
   d. Add field measures including pocket penetrometer[1] and pattern classes (grass fragmentation, soil crust/pedoderm, erosion pattern) (Bestelmeyer et al., 2006).
   e. Use NRCS National Soil Survey Laboratory services.
   f. Evaluate options to summarize data.

### Project Objective and Sampling Design

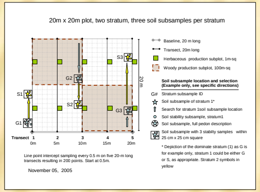
**Are the soil and vegetation properties different for 2 plant communities (state phases) representing 2 states and occurring on the Begay soil of the Semi-desert Sandy Loam (Fourwing Saltbush) (MLRA-35) ecological site?**

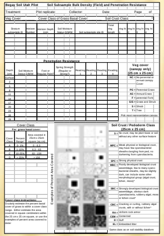
Perennial grass/shrub community (PGS)

Annual grass (cheatgrass) invaded community (AG)

Sampling design - The extent of sampling was limited to areas of Begay fine sandy loam, 1-6% slopes (Coarse-loamy, mixed, superactive, mesic Ustic Haplocambids) in Arches and Canyonlands National Parks. Data collection was organized within randomly located 20 x 20 m plots. Four plots were in the mixed perennial grass/shrub community (PGS) and 4 in the annual grass (cheatgrass) invaded community (AG).

**Replicate plots:** 4 per plant community
**Soil subsample locations:** 4 or 6 per plot
**Sampling depths:** 0-2 cm, 2 cm to the base of the A horizon, the B horizon to 25 cm
**Soil properties:** particle size, OC, CaCO3, active C[2], bulk density, CEC, EC, pH
**Field measurements:** soil aggregate stability, surface crust/pedoderm class), penetration resistance[1]
**Vegetation:** Canopy and basal gap, line point for cover and species, herbaceous and woody annual production



### Lessons Learned

- Data collection was time-consuming, but generally user-friendly, and would be feasible for benchmark soils in an update soil survey.
- Sample during periods with ideal vegetation and soil moisture/temperature conditions.
- Workload: 6-7 hours per plot for 3.5 people (2 soil scientists, 1 range specialist and 1 archeologist). Project total = 142 horizons.
- The sampling intensity was too low to summarize the soils data at the level of strata (shrub vs shrub-intershrub).
- A variety of measures of central tendency (mean, median) and variation (standard deviation, CV, variance) should be developed to meet multiple user needs (Table 1).
- Streamline the plot selection process.

[1] Penetration resistance was measured at 3cm intervals from 2cm to 29 cm with a pocket penetrometer.
[2] For the active carbon method, refer to Weil et al. (2003) and the Soil Survey Laboratory Procedures Manual, SIR No. 42.

## Springfield Plateau (MO, 2005-2007)

### Technology Development Objectives

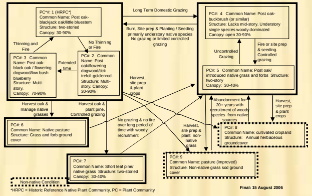
1.Apply the comparison study approach for documenting soil properties that change with vegetation and land use changes.
2.Use a state and transition model of vegetation dynamics to select a forestland plant community.
3.Test a paired sampling approach for forest and pasture.
4.Identify necessary pasture and forest vegetation methods and attributes to validate the plant community and provide context for interpretation of dynamic soil properties.

### Project Objective and Sampling Design

**How do soil properties vary with vegetation and land use on fragipan soils in forest and pasture vegetation states of the Upland Flatwoods ecological site in the Missouri Ozarks?**

Forest (#3)

Pasture (#9)




The *Upland Flatwoods* was the target Ecological Site. Plant Communities targeted for sampling were *#3: post oak – black oak / flowering dogwood / low bush blueberry*, (forest), and *#9: pasture (improved)* (pasture).

Sampling design - The extent of sampling was limited to areas of Tonti (Fine-loamy, mixed, active, mesic Typic Fragiudults) and Viraton (Fine-loamy, siliceous, active, mesic Oxyaquic Fragiudalfs) map units. Even though the named components of these map units are in different soil orders, the fragipan limits the root zone to well above the taxonomically critical depth for Ultisol/Alfisol distinction. Five site pairs were selected by soil-vegetation teams, with forest and pasture in close proximity, in an effort to minimize effects not due to vegetation management. At each site, three soil pedons were located within each vegetation.

**Replicate sites:** 5 per plant community
**Soil subsample locations:** 3 per site
**Sampling depths:** by horizon to the fragipan
**Litter:** dry weight from 1m[2] subplot
**Soil properties:** phosphorous (Bray), particle size, Ca, Mg, K, Na, CEC-7, ECEC, BS, pH, active C[2], particulate organic matter, wet aggregate stability, and bulk density
**Field measurements:** penetration resistance[1]
**Vegetation – forest:** nested series of circular plots for overstory, understory, and ground cover
**Vegetation – pasture:** pasture condition index, line point for cover and species (5 transects per site)

Locations of pedons sampled within the forest and pasture plant communities of the Bear Creek site.

### Lessons Learned

- Pasture soils are higher in bases, pH, and related properties. There were few differences related to organic carbon or bulk density.
- Pairing forest and pasture sites across a fenceline is not recommended for future projects. It increased the difficulty of finding suitable sites, and probably decreased the quality of the pasture sites.
- Forest inventory techniques worked well and have provided data for this ecological site description.

## Northern Idaho (ID, 2006-2007)

### Technology Development Objectives

1. Apply the comparison study approach to characterize management efforts on western coniferous forests.
2. Use a state and transition model to select plant communities.
3. Identify a minimum set of forest vegetation and forest floor attributes to validate the plant community and provide context for interpretation of dynamic soil properties. Select from standard NRCS and FS methods.
4. Test soil disturbance visual classes and soil surface cover transects for assessing forest soil quality. (New methods under development by the FS.)
5. Identify new kinds of information, including soil biological measures, that are useful to managers and can be included in soil survey updates and ecological site descriptions.

### Project Objective and Sampling Design

**What effects have the last century of timber extraction and management activities had on the soil and vegetation properties of ash capped soils of the Threebear series in Northern Idaho?**

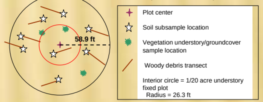
Mature forest community

Clearcut and planted community

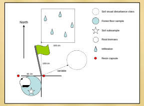
Sampling design - The extent of sampling was limited to all map units containing Threebear ashy-silt loam, 0-40% slopes on similar aspects (Ashy/loamy amorphic/mixed, superactive, fridid Alfic Udivitrands) and similar soils with slightly different ash mantle thicknesses. Data collection was organized within nested circular plots around a common plot center. Plot centers were randomly located. Five stands were in a mature forest having experienced little or no management activity. Five stands had experienced the same form of timber harvest (clearcut) and slash disposal at roughly the same time (30-40 years ago).

**Replicate plots:** 5 per plant community
**Soil subsample locations:** 8 per plot
**Sampling depths:** O horizon, upper 0-2 cm of first mineral layer, and then by horizon to 40 cm below the mineral surface
**Forest floor (O horizon):** total mass, OM loss on ignition, total C, N from 30 cm dia subplot
**Soil properties:** particle size or properties for andic soil material, extractable bases (Ca, Mg, K, Na), CEC-7, ECEC, pH, total C, N, active C[2], and bulk density. wet aggregate stability, microbial biomass, phospholipid fatty acids (PLFA) for top 2 or 3 mineral layers
**Field measurements:** penetration resistance[1] (3 locations per plot), infiltration (5 locations per plot)
**Other measurements:** root biomass for upper 10 cm of first mineral layer (3 locations per plot); two resin capsules for 1 year at each of 3 depths to measure nutrient flux in the soil pore solution (one location per plot)
**Vegetation:** nested series of circular plots for overstory (variable radius plot), high understory, low understory
**Forest floor conditions:** down woody debris, soil disturbance visual classes (8 transects per plot for each)

¼ Acre Plot (radius 58.9 ft)




Soil subsample location



### Lessons Learned

- Collaboration (NRCS, Forest Service, University of Idaho and Intermountain Forest Tree Nutrition Cooperative) helps identify common goals, broaden available expertise, disperse workloads, and maximize the utility of sampling efforts.
- Stand management information (from FS) helped identify potential areas for plots.
- Careful planning of logistics and design of sampling forms greatly simplified field efforts and allowed a large crew to complete all 10 plots in 10 days.
- Workload: 6 hr per plot for 9 soil scientists; 4 hrs per plot for 2 foresters and 3 vegetation technicians, 3 hrs per plot for woody debris and soil disturbance class. Project total = 80 organic horizons and 278 mineral horizons.

## Conclusions

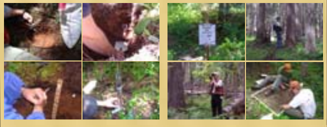
- For these studies, plots must be located on the same soil and in the proper plant community. It is essential that a soil scientist and vegetation specialist work together in the field to select suitable sampling locations. Availability of a well-prepared ecological site description and state and transition model at the onset of a project greatly reduces the project planning time.
- To maximize the utility of the data, it is important to distribute plots throughout the entire extent of the target soil map unit component phase within an MLRA. Interpretive value of results increases when the soil investigated is representative of a larger group of soil series.
- Standardized methods and intuitive data collection forms are essential and help simplify data entry, preparation.

Table 1. Data Summary for Arches National Park Pilot Project
Descriptive statistics for the intact mixed perennial grass/shrub community (PGS) and the annual grass (cheatgrass) invaded community (AG) (n=4). Bulk density and OC % are reported for depths as sampled. Organic carbon (kg/m2) is reported for prescribed depths because horizon depths varied at each location sampled. When compared to the perennial grass-shrub community, soils under cheatgrass have a significantly higher organic carbon content in "2 cm to the base of the A horizon" layer, suggesting that OC accumulation under cheatgrass is primarily in the A horizon below 2 cm.

| | | Perennial grass-shrub | | | Annual grass (cheatgrass) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Property** | **Depth** | **Mean** | **SD** | **CV (%)** | **Mean** | **SD** | **CV (%)** | ***t*** | ***p*-value** |
| Bulk density-field (gm/cm³) | | | | | | | | | |
| | 0-2 cm | 1.51 | 0.04 | 3 | 1.42 | 0.10 | 7 | -1.84 | 0.14 |
| | 2 cm to base of A | 1.51 | 0.07 | 5 | 1.42 | 0.06 | 4 | -1.97 | 0.10 |
| | B horizon to 25 cm | 1.55 | 0.03 | 2 | 1.51 | 0.03 | 2 | -1.90 | 0.11 |
| Organic C (%) | | | | | | | | | |
| | 0-2 cm | 0.59 | 0.07 | 12 | 0.67 | 0.12 | 18 | 1.22 | 0.28 |
| | 2 cm to base of A | 0.27 | 0.02 | 9 | 0.36 | 0.06 | 17 | 2.87 | 0.05 |
| | B horizon to 25 cm | 0.18 | 0.04 | 22 | 0.18 | 0.06 | 33 | -0.11 | 0.92 |
| Organic C (kg/m²) | | | | | | | | | |
| | 0- 2 cm | 0.18 | 0.02 | 14 | 0.19 | 0.03 | 17 | 0.58 | 0.58 |
| | 2-10 cm | 0.28 | 0.04 | 15 | 0.38 | 0.06 | 15 | 2.75 | 0.04 |
| | 10-25 cm | 0.42 | 0.09 | 21 | 0.42 | 0.10 | 25 | -0.06 | 0.96 |
| | 0-25 cm | 0.88 | 0.14 | 16 | 0.98 | 0.12 | 12 | 1.12 | 0.31 |
| Soil aggregate stability | | | | | | | | | |
| | Surface | 5.1 | 0.10 | 2 | 4.5 | 0.80 | 18 | -1.38 | 0.26 |
| | 2.5 cm | 2.2 | 0.75 | 35 | 2.4 | 1.01 | 43 | 0.32 | 0.76 |
| Canopy cover (%) | | 47.6 | 9.6 | 20 | 77.0 | 12.7 | 17 | 3.68 | 0.01 |
| Annual production (lbs/ac) | | | | | | | | | |
| | Herbaceous | 254 | 110 | 43 | 666 | 96 | 14 | 5.64 | 0.001 |
| | Woody | 269 | 182 | 68 | 0 | 0 | | -2.97 | 0.06 |
| | Total | 523 | 177 | 34 | 666 | 96 | 14 | 1.42 | 0.22 |

SD (standard deviation); CV (coefficient ofvariation); Organic C = total C minus $CaCO_3$- C
Annual production not adjusted for seed shattering.

- By sampling via pedogenic horizons rather than pre-specified depth increments, we avoided mixing unlike materials and had greater flexibility for data manipulation. However, the process of adjusting for horizon differences among pedons was time-consuming and confusing.
- Methods to compare results are needed 1) for samples with unlike horizon sequences and 2) to evaluate the vertical redistribution in the profile. Software macros or simple programs should be developed to assist data preparation and analysis for comparisons.
- Plans are underway for a pilot study on cropland.



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