

# Opportunities to Utilize the USDA-ARS Northern Great Plains Research Laboratory Soil Sample Archive

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Archived soil samples are an important resource for quantifying changes in soil attributes over decadal time scales. Herein, we describe a soil archive at the USDA-ARS Northern Great Plains Research Laboratory (NGPRL) near Mandan, ND with the intent of encouraging research collaboration through utilization of the archive. Over 5000 samples are included in the NGPRL soil archive, ranging in age from 4 to 90 yr. Samples were derived from both grazing and cropping studies, with the former being conducted near Mandan, and the latter as a part of an evaluation of soil C and N change at multiple locations throughout the Great Plains. Most samples are associated with soil depths above 30.5 cm, although 10 locations from the Great Plains evaluation possess archived soils below 1 m for native vegetation treatments. Collaborative research opportunities using the NGPRL soil archive abound, and may include characterizations of soil organic matter fractions, micronutrients, and soil acidity. Scientists interested in engaging in collaborative research efforts are encouraged to contact the authors of this report.

Abbreviations: LTSE, long-term soil experiment; NGPRL, Northern Great Plains Research Laboratory.

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SUSTAINING HIGHLY PRODUCTIVE AND ENVIRONMENTALLY SOUND agroecosystems will be a significant challenge over the next several decades given projections for human population growth and global climate change in an increasingly urbanized world (Brown, 2006). Because of these conditions, long-term soil experiments (LTSEs) will play an essential role in understanding how agroecosystems affect soil attributes—and, in turn, how changes in soil attributes impact the broader environment (Richter et al., 2007). Documenting management effects on soil attributes requires not only well-managed LTSEs with standardized sampling protocols and laboratory analyses, but also carefully cataloged soil archives. Archived soil samples provide 'time capsules' for determining temporal changes in soil attributes, and are particularly valuable as new analytical capabilities are developed (Boone et al., 1999).

The NGPRL was established in 1912 near Mandan, ND (46°48' N; 100°54' W) to respond to the needs of farmers and ranchers in the northern Great Plains. In the 1940s, a soil archive was initiated at NGPRL to provide the opportunity for temporal characterizations of long-term grazing and cropping management practices on soil attributes. In addition to soils from on-site studies, samples from locations throughout the Great Plains were archived as part of a regional assessment of cropping effects on soil C and N (Haas et al., 1957).

In this report we briefly describe the sample inventory currently housed in the NGPRL soil archive. We hope that by sharing this report, collaborative research efforts may be developed using the archive.

## ARCHIVE DESCRIPTION

The NGPRL soil archive includes over 5000 samples. Samples are generally categorized in two groups: pasture evaluations and Haas et al. evaluations (Table 1). Samples from pasture evaluations include seven projects where investigations of grazing and seeding management practices were conducted near Mandan, ND on a nearly homogeneous soil type (Temvik-Wilton silt loam; Fine-silty, mixed, superactive, frigid Typic and Pachic Haplustolls). Among the seven evaluations, the grazing intensity study is ongoing, and has been the source of numerous investigations since its inception in 1916 (Sarvis, 1941; Rogler, 1951; Frank et al., 1995; Phillips et al., 2006). Specific sampling locations for archived samples are unknown, but can be generally located based on knowledge of previous (and in some cases, present) borders for pasture treatments. Samples from the pasture evaluations were collected from 1957 to 2003 to depths of 106.7 cm, though early evaluations (1957–1960) were sampled only to 60.9 cm.

The bulk of the NGPRL soil archive is from the Haas et al. evaluations, where samples from 15 locations throughout the U.S. Great Plains were collected to quantify loss of soil C and N as a result of conversion of native vegetation to dryland cropping. For most locations, treatments evaluated by Haas et al. included cropping treatments under various crop sequences and fertility regimes (e.g., manure, no manure), as well as native vegetation. Similar to the pasture evaluation samples, sampling locations within each of the study sites is unknown, but may be geographically constrained based on knowledge of soil type (where reported). Most samples were collected in 1947 and 1950, though some were collected as early as 1917 (Sheridan, WY) and as late as 1953 (Mandan, ND). All sampled locations possess archived soils from the 0- to 15.2-cm depth. Soils from depths below 15.2 cm are also archived for most locations, while 10 locations possess archived soils to depths below 1 m under native vegetation.

**Table 1. Inventory of archived soil samples at NCPRL.**

Location	Treatment	Depth (cm)	Year	No. Samples
Pasture evaluations (Mandan, ND)				
Crested wheatgrass seeding study	Crested Broadcast/Drilled	0-15.2, 15.2-30.5, 30.5-60.9	1957	36
Grazing intensity study	Native Broadcast/Drilled			
Pasture comparison study	Stocking rates (3)	0-15.2, 15.2-30.5, 30.5-45.7, 45.7-60.9	1959	108
Native range seeding study	Grazing management systems	0-15.2, 15.2-30.5, 30.5-45.7, 45.7-60.9	1959, 1960	336
Grazing intensity study	Drilled spray/No spray	0-15.2, 15.2-30.5, 30.5-45.7, 45.7-60.9	1960	48
	Broadcast spray/No Spray			
	Stocking rates (2) and enclosure	0-7.6, 7.6-15.2, 15.2-22.8, 22.8-30.4, 30.4-45.9, 45.6-76.2, 76.2-106.7	1991	168
Improved pastures study	Crested wheatgrass, Western wheatgrass	0-7.6, 7.6-15.2, 15.2-22.8, 22.8-30.4, 30.4-45.9, 45.6-76.2, 76.2-106.7	1991	252
	Smooth bromegrass			
	Hayed, Grazed, Ungrazed			
Pasture comparison study	Grazing management systems	0-5.0, 5.0-10.0, 10.0-20.0, 20.0-30.0, 30.0-60.0, 60.0-100.0	2003	81-
Haas et al. evaluations				
Akron, CO	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947	317
	Native vegetation (Rago silt loam) <sup>†</sup>	0-17.8, 17.8-30.5, 30.5-45.7, 45.7-71.1, 71.1-83.8, 83.8-106.7, 106.7-129.5, 129.5-152.4		
Archer, WY	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947	58
	Native vegetation (Altvan loam)	0-15.2, 15.2-25.4, 25.4-45.7, 45.7-55.9, 55.9-76.2, 76.2-94.0, 94.0-139.7		
Big Spring, TX	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947, 1950	100
	Native vegetation (Amarillo fine sandy loam)	0-17.8, 17.8-30.5, 30.5-45.7, 45.7-60.9, 60.9-76.2, 76.2-99.1, 99.1-121.9, 121.9-160.0, 160.0-170.2		
Colby, KS	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947	39
	Native vegetation (Sherman silt loam)	0-5.1, 5.1-17.8, 17.8-25.4, 25.4-43.2, 43.2-53.3, 53.3-73.7, 73.7-96.5, 96.5-114.3, 114.3-152.4, 152.4-182.9		
Dalhart, TX	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947, 1950	81
	Native vegetation (Dalhart loam)	0-15.2, 15.2-30.5, 30.5-43.2, 43.2-66.0, 66.0-88.9, 88.9-116.8, 116.8-144.8, 144.8-160.0		
Dickinson, ND	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947	151
	Native vegetation (Morton loam)	0-15.2, 15.2-30.5, 30.5-61.0, 61.0-99.1, 99.1-132.1, 132.1-157.5		
Garden City, KS	Crop rotation	0-15.2	1950	10
Havre, MT	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947, 1950	160
	Native vegetation (Ioplif clay)	0-10.2, 10.2-30.5, 30.5-48.3, 48.3-73.7, 73.7-101.6, 101.6-132.1		
Hays, KS	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947, 1950	60
	Native vegetation (Munjor silty clay loam)	0-15.2, 15.2-30.5, 30.5-38.1, 38.1-48.3, 48.3-71.1, 71.1-88.9, 88.9-109.2, 109.2-142.2, 142.2-160.0		
Huntley, MT	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947	108
Lawton, OK	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947	89
	Native vegetation (Lawton silt loam)	0-15.2, 15.2-30.5, 30.5-38.1, 38.1-48.3, 48.3-76.2, 76.2-88.9, 88.9-114.3, 114.3-137.2, 137.2-154.9		
Mandan, ND	Crop rotation, Native vegetation, Pasture	0-15.2, 15.2-30.5, 30.5-60.9	1947, 1950,	886
	Native vegetation (Cheyenne fine sandy loam)	0-15.2, 15.2-30.5, 30.5-45.7, 45.7-71.1, 71.1-99.1, 99.1-121.9, 121.9-144.8, 144.8-152.4, 152.4-182.9	1951, 1953	
Moccasin, MT	Crop rotation, Native vegetation	0-15.2, 15.2-30.5	1947, 1950	125
Sheridan, WY	Crop rotation (w/and w/o manure)	0-15.2, 15.2-50.8	1917, 1927, 1937	1572
		0-16.7, 16.7-50.8	1947, 1949, 1950	
Woodward, OK	Crop rotation	0-15.2, 15.2-30.5, 30.5-45.7, 45.7-60.9	1940, 1948	217

<sup>†</sup> Soil series listed for native vegetation treatments taken from Haas et al. (1957).

The sample archive is housed in a building approximately 1 km south of the NGPRL main campus. Most samples from the pasture evaluations are stored in 0.95-L paper cups, while the Haas et al. samples are stored in glass jars ranging in volume from 0.25 to 2 L. All samples were ground to pass a 2-mm (No. 10) sieve before archiving. Some samples are finely ground (e.g., 1991 pasture evaluation samples and Haas et al. samples from Sheridan, WY). Sample amounts vary considerably, ranging from 0.02 to 3.2 kg sample<sup>-1</sup>.

## RESEARCH OPPORTUNITIES

There are numerous opportunities for research using the NGPRL soil archive; opportunities that on-site personnel realize will only be brought to fruition through collaborative efforts with other researchers. A partial list of opportunities includes:

- *Detailed characterizations of soil organic matter fractions (including radiocarbon assessments for 'pre-bomb' samples).* Characterizations of soil organic matter fractions would provide important information concerning soil C and N dynamics in semiarid agroecosystems. In particular, evaluation of samples collected under native vegetation may provide a unique opportunity to document changes in soil attributes relevant to global change research (Rasmussen et al., 1998; Richter and Markewitz, 2001). Additionally, analysis of soil organic matter fractions from pre- and post-bomb samples may provide differing ratios of stable (<sup>13</sup>C) and radiogenic (<sup>14</sup>C) isotopes (Bird et al., 1996; Follett et al., 2007), thereby allowing for estimations of fraction age.
- *Analyses of micronutrient content.* Micronutrients are needed for optimal crop growth, yet many soils are deficient in more than one element (White and Zasoski, 1999). Furthermore, long-term cultivation effects on micronutrient levels in soil are poorly understood (Moraghan and Mascagni, 1991). Micronutrient analyses of archived soil samples may provide useful information for documenting temporal changes resulting from agricultural management for key elements.
- *Characterization of soil acidity.* Cropping practices have been found to affect soil acidity, which, in turn, has been linked to lowered nutrient retention and cycling potential (Barak et al., 1997; Liebig et al., 2002). Changes in soil acidity and associated soil properties (e.g., exchangeable Ca and Mg, weathering attributes of clay minerals, etc.) generally occur on a decadal time scale, thereby making the availability of soil archives an important resource for understanding agroecosystem impacts on long-term changes in soil fertility.

An overarching potential outcome from collaborative research using the NGPRL soil archive includes a more in-depth understanding of long-term agroecosystem effects on soil. Such an outcome is particularly valuable for the region associated with the archive's domain (semiarid Great Plains), as changes in soil properties resulting from management in this region can take decades to be expressed (Mikha et al., 2006). Consequently, the NGPRL soil archive can play an important role in assessing the long-term viability of semiarid agroecosystems.

Scientists interested in utilizing the soil archive through collaborative research efforts with on-site personnel are encouraged to

contact the authors of this report. Proposals to utilize the archive will be considered on a study-by-study basis. Initiation of collaborative research efforts will rely on somewhat flexible criteria taking into consideration the potential of the proposed study to add new and useful information to previous evaluations, availability of on-site resources for supplementary analyses, and the likelihood of achieving publishable results. Studies minimizing destructive sampling of archived samples will be given preference. As results from collaborative efforts are published, an on-site database specific to the NGPRL archive will be developed as an information resource for researchers in the soil science, ecological, and agronomic disciplines. This database will also serve to effectively direct new collaborative research efforts.

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