Jim

United States Department of Agriculture

Natural Resources Conservation Service

11 Campus Boulevard
Suite 200
Newtown Square, PA 19073
Phone 610-557-4233; FAX 610-557-4136

Subject: SOI - Geophysical Assistance

Date: September 11, 2001

To: Stephen K. Chick
State Conservationist
NRCS, Lincoln, Nebraska

Purpose:
At the request of the Conservation and Survey Division, University of Nebraska at Lincoln, the potential of using ground-penetrating radar (GPR) to help characterize soil, stratigraphic, and landscape features within the Sandhills of western Nebraska was evaluated.

Participants:
Jim Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
Chuck Markley, Soil Scientist, USDA-NRCS, North Platte, NE
Jim Roberts, Driller, Conservation and Survey Division, University of Nebraska, Lincoln, NE
Phil Schoeneberger, Research Soil Scientist, USDA-NRCS-NSSC, Lincoln, NE
David Vyain, Soil Scientist, USDA-NRCS, Valentine, NE
Denise Walley, Technician, Conservation and Survey Division, University of Nebraska, Lincoln, NE
William Zanner, Conservation and Survey Division, University of Nebraska, Lincoln, NE

Activities:
All field activities were completed on 6 and 7 September 2001.

Recommendations:

1. GPR is an appropriate tool for soil investigations (upper 3 m of earthen materials) with the Sandhills.

2. Using lower frequency (< 200 MHz) antennas can increase the depths of penetration. However, it is doubtful that a significant increase in the depth of penetration can be obtained even with lower frequency antennas to permit GPR stratigraphic and hydrologic investigations within the Sandhills. Base on results from this study, GPR appears to be an inappropriate tool for deep (greater than 4 to 5 m) investigations within most areas of the Sandhills.

3. With adequate soil sampling tools and survey designs, GPR can be used to complement tradition survey techniques and help characterize near surface soil and hydrologic properties within many Sandhill fens. The use of electromagnetic induction methods should also be explored especially in fens that are calcareous or saline.

4. Upon completion of my extend field assignments in November, I will prepare bitmaps of the radar profiles obtained during this study. Copies of these files will be sent to Dr Zanner.

I wish to commend the enthusiasm and efforts of Dave Vain and Chuck Markley. Their knowledge of the soils and landscapes of the Sandhills were of great valuable to the principal investigators.

Jim Doolittle

JAMES A. DOOLITTLE
Research Soil Scientist

cc:
Robert J. Ahrens, Director, National Soil Survey Center, MS 32, NRCS, Lincoln, NE
Carolyn G. Olson, National Leader for Soil Survey Investigations, NSSC, MS 34, Lincoln, NE
Steve Scheinost, Acting State Soil Scientist, NRCS, Lincoln, NE
Phil Schoeneberger, Research Soil Scientist, NSSC, MS 34, NRCS, Lincoln, NE
Horace Smith, Director, Soil Survey Division, NRCS, Washington, DC

Equipment:
The radar unit is the Subsurface Interface Radar (SIR) System-2000, manufactured by Geophysical Survey Systems, Inc.[1] The SIR System-2000 consists of a digital control unit with keypad, VGA video screen, and connector panel. A 12-volt battery powered the system. This unit is backpack portable and, with an antenna, requires two people to operate. The 400 and 200 MHz antennas were used in this study. The range gain and filtration settings, and scanning times (70 to 110 nanoseconds (ns)) were varied based on desired observation depth and resolution of subsurface features. Hard copies of the radar data were printed in the field on a model T 104 printer.

Study Areas:
Study sites were selected at the Gudmundsen Sandhill Laboratory in northeast Grant County and the Jumbo Valley Fen in western Cherry County. The University of Nebraska at Lincoln manages the Gudmundsen Sandhill Laboratory. A restoration project sponsored by the Sandhills Taskforce and The Nature Conservancy is in progress at Jumbo Valley Fen. Soil, hydrologic, and biological information obtained from this project will be used to help restore the distinctive characteristics of other fens in western Nebraska. As part of this study, researchers are gathering information on the depth and distribution of sand layers within the peat deposits of Jumbo Valley Fen. This information will provide insight into the fen's hydrology and development.

Field Procedures:
Traverse lines were established across each site. Within the Gudmundsen Sandhill Laboratory, radar traverses were competed in areas of Valentine soil. The very deep, excessively drained Valentine soil formed in eolian sands on dune and interdune areas of the Sandhills. The Valentine series is a member of the mixed, mesic Typic Ustipsamments family. Typically the texture of the control section is fine sand or loamy fine sand. The official series description for Valentine series notes "In some pedons, dark colored loamy textured strata ranging from 1/8 to 2 inches in thickness are below depths of 20 inches. When Valentine soils are associated with clayey soils, clayey substratum phases are recognized at 40 to 80 inches."

A traverse line was established across a portion of Jumbo Valley Fen. The line ran from near one edge to almost the center of the fen. This line crossed delineated areas of Loup and Cutcomb soils. The very deep, poorly and very poorly drained Loup soil formed in sandy alluvium in interdune areas of the Sandhills. The Loup series is a member of the sandy, mixed, mesic Typic Endoaquolls family. The very deep, very poorly drained Cutcomb soil formed in organic materials on interdune areas of the Sandhills. The Cutcomb series is a member of the euic, mesic Typic Medihemists family.

Upon completion of each survey, radar profiles were printed and reviewed. Interpretations were discussed in the field. At each site, soil borings were conducted at several observation points to confirm interpretations.

Results:
Ground-penetrating radar was found to be a suitable tool for soil investigations within the Sandhills. In the investigated areas of Valentine soil, the 200 MHz antenna provided high-resolution profiles to depths of about 3 m. Below this depth, radar reflections were exceedingly weak and indistinguishable from background noise. Attenuation of the radar signals is attributed principally to clays within thin bands of lamellae. The texture of these lamellae is loamy sand. The fines are dominated by 2:1 expanding lattice clays.

In areas of Valentine soils, the radar distinguished buried A horizons with lower values and chromas, but similar textures to the contiguous C horizons. Other than soil color, these horizons were not considered contrasting. It

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[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

was unexpected that the radar would detect these paleosols. The radar also distinguished thin bands of lamellae and wetting or moisture fronts in the soil profile.

The soil was dry at the time of this investigation. Based on calibration trials, the dielectric permittivity and the velocity of propagation within the upper part (0.75 m) of the soil profiles were 6.3 and 0.1198 m/ns. Radar interpretations were confirmed at two observation points. A buried A horizon (paleosol) and bands of lamellae were observed in both profiles. The paleosol occurred at depths of 46 and 32 inches. The interpreted depths to these two interfaces were 45 and 32 inches, respectively. The bands of lamella occurred at depths of 92 and 69 inches. The interpreted depths to these two interfaces were 79 and 68 inches, respectively. The disparity between the first set of measurements (92 inches measured and 79 inches interpreted) was attributed to a band of moist soil overlying the lamella layer.

In areas of Cutcomb soils, numerous subsurface, near-horizontal, reflectors were observable on radar profiles. The number and alignment of these reflectors made interpretations problematical even with modest ground-truth observations. The radar distinguished a wedge of sands that extended into the fen. The sands were composed of multiple inclined layers that sloped into the fen. The interface separating the overlying mineral layers from the underlying organic materials produced a strong subsurface reflection. With increased distance into the fen the layers of sandy materials were overlain by increasingly thicker layers of organic materials. The layers of sands had become interleaved between layers of organic materials. The overlying organic materials were generally devoid of conspicuous (high amplitude) internal reflectors, but did contained several obscured to weakly expressed subsurface layers. These layers were believed to represent slight differences in degrees of humification. At a distance of about 300 from the beginning of the traverse line, the sand wedge was no longer distinguishable. However, a prominent interface separating the more recently deposited organic materials from the older organic materials that formerly layed beneath the mineral wedge continued across the fen. The lower boundary of the older organic materials was below a depth of 110 inches and could not be confirmed with the soil auger.

At Jumbo Valley Fen, radar interpretations were confirmed at four observation points along the traverse line. Not all interfaces were identified. Measurements and interpretations were restricted to the upper 95 to 110 inches of the soil profile. The velocity of propagation decreases with increasing soil moisture content. Based on data obtained within the upper meter of the soil profile, the velocity of propagation decreased from 0.0674 to 0.0454 m/ns within the first 300 feet of the traverse line. The soil moisture content noticeably increased within the upper part of soil profiles along this portion of the traverse line. The soil moisture content increased with depth and spatially with greater distance into the fen (the water table rose and the peat content and composition changed). This produced depth-scaling and interpretation problems.