United States Department of Agriculture | **Natural Resources Conservation Service** | **11 Campus Boulevard, Suite 200 Newtown Square, PA 19073**

Subject: Soil – Joint USDA - NRCS & ARS Red River Valley of the North Salinity Project

Date: July 6, 2006

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Purpose:
Salinity is a major cause of soil degradation and reduced crop production in MLRA (major land resource area) 56, the Red River Valley of the North. Salinity also has a major impact on crop production in surrounding areas. Since 1993, partially in response to a wetter weather patterns, areas of salt-affected soils have grown considerably in this resource area. Seasonal high water tables and capillary rise are responsible for the ascent of saline ground water into soil profiles. This report summarizes the results of a preliminary salinity tour of the Red River Valley of the North. The purpose of this tour was to acquaint participants with the properties and distribution of saline soils within the *Valley*, to promote discussions, formulate research and mapping objectives, and develop plans of operation.

Principal Participants:
Keith Anderson, MLRA Project Coordinator, USDA-NRCS, Fargo, ND
Matt Baltes, GIS Specialist, USDA-NRCS, Thief River Falls, MN
Mike Collins, ASTC (FO), USDA-NRCS, Jamestown, ND
Dennis Corwin, Soil Scientist, USDA-ARS, U.S. Salinity Laboratory, Riverside CA
Jim Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
Scott Lesch, Principal Statistician, USDA-ARS, U.S. Salinity Laboratory, Riverside CA
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Brandon Schwab, WAE, USDA-NRCS, Thief River Falls, MN
Michael Ulmer, Soil Data Quality Specialist, USDA-NRCS, Bismarck, ND

Activities:
All field activities were completed during the period of 12 to 15 June 2006. Areas of salt-affected soils were visited in Cass, Grand Forks, Pembina, and Walsh Counties in North Dakota, and Clay and Kittson Counties in Minnesota. On the first day (Monday), Jim Richardson provided insight and led field discussions on the causes,

properties, and distribution of saline soils in Cass, Clay, and Grand Forks Counties. On Tuesday, discussions with landowners and land use managers were held in Pembina and Walsh Counties. On Tuesday afternoon and Wednesday, Dave Potts provided a comprehensive overview of the saline soils in Kittson County and the procedures that he has used to record and map salinity. On Wednesday afternoon and Thursday morning plans were developed for evaluating and mapping soil salinity at varying spatial scales and levels of resolution in Kittson County, the Red River Valley of the North, and on individual parcels of land. This tour provided an excellent overview of salinity within MLRA 56. The tour also provided opportunities for each participant to express their needs, concerns, and strategies for undertaking soil salinity assessments.

Summary:

A. Kittson County Soil Salinity Survey:

The soil survey update of Kittson County, Minnesota, is scheduled to be completed in the spring of 2007. Dennis Corwin and Scott Lesch have agreed to analyze the collected salinity, EMI (electromagnetic induction), and soil characterization data. To assist this effort, Dave Potts will continue to collect EMI and $EC_{1:1}$ (electrical conductivity) data during this field season. Dave will focus on collecting additional EMI and $EC_{1:1}$ sampling sites that fill in spatial gaps and provide increased data coverage. Additional observations will also be made in bordering non-saline areas. Sampling will be modified to expedite this process. Instead of collecting transect data, sampling will consist of a single georeferenced observation point. At each observation point, soil samples will be collected at three depth intervals (0 to 30, 30 to 60, and 60 to 90 cm) for determination of the $EC_{1:1.}$ EMI data (collected in both the horizontal and vertical dipole orientations) will be collected at each observation point with an EM38 meter. As statistical analysis will be restricted to single observation points, the collection of multiple (5 measurement points) EMI measurements along transect lines will be discontinued.

Matt Baltes will supply Scott Lesch (USDA-ARS) with all EMI and $EC_{1:1}$ data collected in Kittson County. As additional data are collected, he will also forward this information to Scott. Matt will use GIS to divide the western 2/3 (principally the lake plain portion) of Kittson County into 40-acre grid cells and furnish data on the dominant soil type and the coordinates of the defined grid intersections (about 12,000 points) to Scott. Data will be *pre-scrubbed* to remove points that are located too close to drainage ditches and not indicative of salinity levels within fields and the encompassing soil polygons. Dave Potts will determine those map units that border the salt-affect areas and are non-saline (for spatial analysis default salinity values (non saline – 0 to 2 mmhos/cm (?) will be assigned to these units). This information will be forwarded to Scott Lesch.

Scott Lesch will conduct geostatistical analysis and spatial regression modeling on the data from Kittson County. As a precursor to the geostatistical analyses, Scott will develop predictive equations that calibrate apparent conductivity (EC_a) data obtained with the EM38 meter to $EC_{1:1}$ data from the 28 pedons from Kittson County that were characterized in 2005 (pedon numbers 06N0013 to 06N0041) at the National Soil Survey Laboratory. Tom Reinsch of the National Soil Survey Laboratory has agreed to provide the $EC_{1:1}$ data from the stored samples. The calibration equations developed by Scott may be useful in future CRP (Conservation Reserve Program) determinations in Kittson County and other areas with fine and very fine textured soils in the *Valley*.

Scott Lesch plans to have salinity *conditioned off* of soil boundaries and *tied down* to soil map units. As a consequence, the model developed by Scott will be forced to follow existing soil polygon boundary lines wherever possible. Scott will provide tabular and spatial estimates of soil salinity for three depth intervals (0-30, 30-60, and 60-90 cm) at each of the 12,000 grid intersections furnished by Matt Baltes. This information, along with the raster maps, will allow Dave Potts to intuitively map the salinity using existing soil polygon boundary lines wherever possible. This will minimize spatial changes to the existing SSURGO data. Where necessary, Dave Potts will adjust or add boundary lines to subdivide some soil polygons into both saline and non-saline units. The tabular and spatial data will also be used to estimate the variability of salinity within soil

map units. Dave Potts and Mike Ulmer are responsible for the development of representative values and ranges in salinity for use in NASIS.

B. Developing salinity surveying protocols for other counties within MLRA 56:

Discussions during the week emphasized the need to develop a consistent, structured approach to validate salinity using EMI technology (EM-38, etc.) as part of routine soil survey procedures. During the salinity tour, perplexing EMI responses were observed in an area of saline soils on Dave Burklund's farm in Grand Forks County, North Dakota. Spatial EC_a patterns did not correspond with patterns of microrelief or crop response. Field soil scientists in North Dakota and Minnesota have also observed high EC_a (>100 mS/m) in areas of apparently low salinity. Jim Doolittle has scheduled a return visit for the week of 21 to 25 August 2006. High-intensity EMI surveys with an EM38DD meter will be completed during Jim Doolittle's visit on several of Dave Burklund's fields. Field data collected each day will be forwarded to Scott Leash each night for analysis through the ESAP program. This program will generate spatial maps, generate multiple field summary statistics, and provide a model-based sampling plan, which will be used to diagnose and identify the principal soil properties that are influencing the EC_a data. Scott Lesch will provide the field crew with the location of sampling points within each field. Soil samples will be collected at these designated points for complete characterization. The assistance of Jim Richardson and Dave Hammer of the National Soil Survey Center in facilitating these analyses through the National Soil Survey Laboratory or the Soils Laboratory at North Dakota State University is requested. Results of this initial investigation will guide the group's future activities within the *Valley*.

Dennis Corwin and Jim Doolittle will return to the Red River Valley in June and August of 2007 to continue field studies and development of survey protocols for assessing soil salinity within the MLRA. EMI surveying protocol will be developed for validating salinity within soil map units. Future sites will be located throughout the *Valley*. As soil salinity commonly occurs in Calciaquolls, initial work will focus on these soils. Wherever possible, EMI data will be correlated with changes in landscape components, management, and crop response. Where trends are not evident, due to variations in other soils properties or management practices, detailed studies and sampling will be carried out to resolve relationships; however, it is hoped that survey protocols will be developed that will minimize soil sampling.

C. Development of a regional approach to soil salinity assessments within MLRA 56:

Near-surface hydrology is the driving force behind the development of soil salinity in the Red River Valley of the North. As a consequence, greater emphasis will be placed on the use of aerial photography and remote sensing to identify areas where saline discharge sites are developing, or where water tables are sufficiently shallow for upward water flow and capillary rise to increase salinity levels in the soil profile. Due to the large spatial extent of the Red River Valley, hierarchical theory suggests that a statistical regression model of salinity development is the most tenable approach; as a result, a *Regional Layered GIS Approach* will be utilized consisting of layers of properties either directly or indirectly related to the development of soil salinity. These potential GIS layers will include: MODIS and aerial imagery, depth to groundwater, groundwater quality (i.e., salinity as measured by EC_e), soil type data from previous soil surveys, Lidar data where available (e.g., Walsh County), DEM data, drainage channel network, precipitation spatial distribution, crop history, and near-surface stratigraphy. Only spatial data will be used that is available without charge. Salinity survey data already completed in Richland and Kittson Counties and fields qualified for the CRP under shallow water areas and alkali fields will be used for model development following the technique of Corwin et al. (1989). Using CRP information as a response variable and the GIS layers as independent variables, a multiple linear regression (MLR) model will be developed for the entire *Valley* following the same general methodology used by Corwin et al. (1989), which mapped the potential for salinity development in the Wellton-Mohawk Irrigation District near Yuma, AZ. MODIS infrared imagery will be analyzed by David Lobell (Lawrence Livermore Laboratory). This imagery is rather coarse (about 1 km), but is available without charge for the whole *Valley*. It is hoped that temperature differences will provide an indication of spatial differences in soil moisture and the location of seep areas and shallow water tables causing salt accumulation in the root zone. Salinity survey data already collected in Richland and Kittson Counties will be used as the validation data set to confirm the MLR model. A salinization potential map will be developed for the MLRA that will subdivide

the region into areas of low, moderate, and high potentials for salinity hazards. If a model performance evaluation of the MLR model yields unsatisfactory results and is statistically untenable, other layers of spatial data will be considered such as Lidar imagery for additional selected counties within the *Valley*, geologic stratigraphy, and higher resolution infrared imagery. Each of these data layers could require a significant expenditure of funds to obtain and can only be considered for specific locations to minimize cost.

The *Regional Layered GIS Approach* will require significant GIS assistance from NRCS. NRCS will assist with data compilation (well data, drainage networks, and lands in CRP). Statistical modeling, imagery interpretations, and data layer development will be carried out by Scott Lesch, Dennis Corwin, and David Lobell. However, the development of the GIS layer will require the assistance of Matt Baltes, Manuel Matos, and Joe Brennan. ARS will specify layers of information that may be pertinent to the development of salinity. NRCS will assist with data compilation (well, drainage networks, CRP data) and review of results. The compilation, manipulation, and organization of the data as well as creation of any maps with GIS will be the responsibility of NRCS.

D. Salinity Summit

The tour primarily focused on identifying and mapping saline areas. However, some time was spent discussing the impact and management of saline soils within the *Valley*. Of concern is the practical utilization of saline data and the benefits to producers for undertaking a project of this scale. This issue was emphasized by discussions with producers and district conservations involved in the tour.

Presently, one of the main programs utilized by NRCS to assist in the management of saline soils is continuous sign-up CRP. This temporary set-aside program does not address the long term impact of salinity on crop production in this important agricultural region. The question was asked by Dennis Corwin, “What if the wet cycle continues for another 10 years?”

It was felt that in conjunction with this technical project, it would be appropriate to gather influential producers, conservations, and soil and/or water board members to have a general discussion on the impact salinity is having in the Valley. If local NRCS staff receives approval for such a meeting, it would be organized by them.

The participants are deeply indebted to the soil survey staffs in North Dakota and Minnesota for their excellent organization, preparation, and leadership of this tour. All participants are indebted to Jim Richardson, USDA-ARS, and Soil Survey of Canada for the groundwork that they have provided to this study.

References:

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With kind regards,

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