Interim Energy Development and Transmission Committee April 10, 2014

Representative Marvin E. Nelson Agricultural Consultant

Agricultural perspective on reclamation of salt affected land



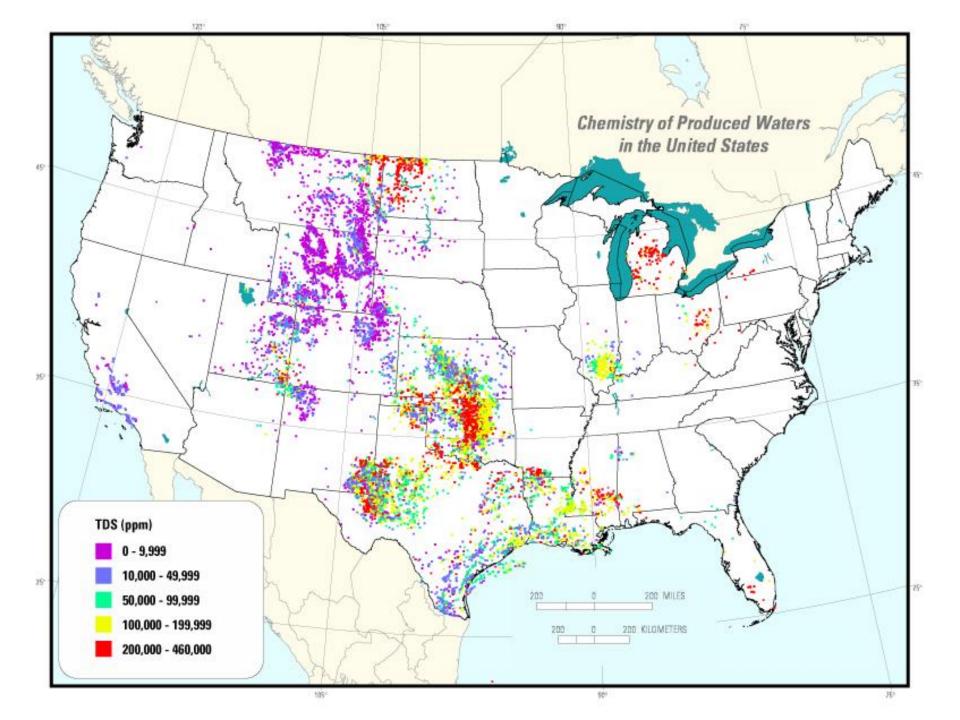
Haas Field, Bottineau County Salted Land Tour #1.

Legacy of Oil and

entiona

Salt Contaminated Land & Water Council, Inc. Fintan L. Dooley, Coordinator 414-731-0520 findooley@wi.rr.com

ton R



Salt

- Halite- NaCl
- Potash KCL
- Calcium Nitrate CaNO3

Cations

• First substance in the chemical formula

• Positive charge

- Soil clays have a relatively large ability to hold cations. Can be tested, cation exchange capacity or CEC
- Na is the cation in NaCL

Anions

- Second part of the chemical formula of a salt
- Negative charge
- Clays don't hold anions very well so they easily leach
- Cl is the anion in NaCL

Soil and Cations

- SAR Sodium Adsorption Ratio Too much sodium causes soil to become impermeable. Ratio changes by clay type and the soil is actually protected to a degree by salts.
- Important not to leach salt unless there is calcium to displace sodium. This is why the Remediation manual says to apply calcium before it rains.
- Much harder to recover after sodium causes soil to become impermeable.
- Soils vary greatly in amounts of cations present.

Remediation needs

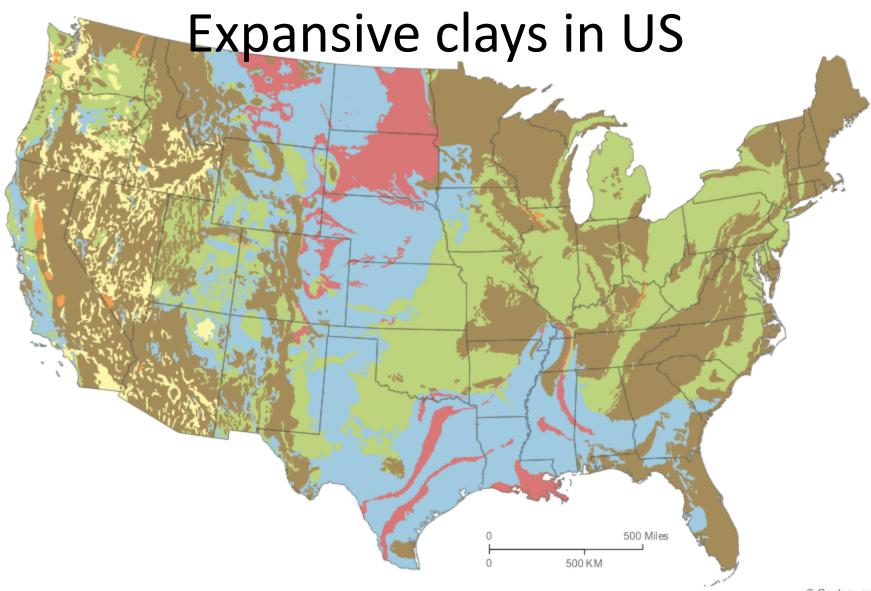
- Need enough other cations, like calcium, to keep sodium from dissociating soil. Can calculate how much you need if you know what you are working with.
- Need excess water to leach.
- Need to get salts out of system, either through leaching to depth or drain tiles.
- Productivity of soil restored, need sufficient depth, 80 inches, to not limit crop production, or previous depth if less than 80 inches.

Soils-Clays

• Montmorillinite (Smectite) shrinking swelling

• Illite

• Kaolinite



© Geology.com

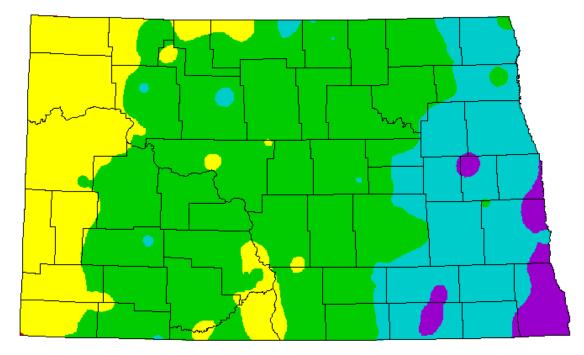
Rainfall

- Need excess water to move salts down below rooting depth or to drain tiles.
- Drain tile only removes free water it removes nothing from normally moist soil.
- Western North Dakota doesn't normally have enough rainfall to properly leach salts.
- Grassland common to see a whitish layer at a couple of feet that is calcium carbonate, tells you the normal wetting depth.

Rainfall in North Dakota

Average Annual Precipitation

North Dakota





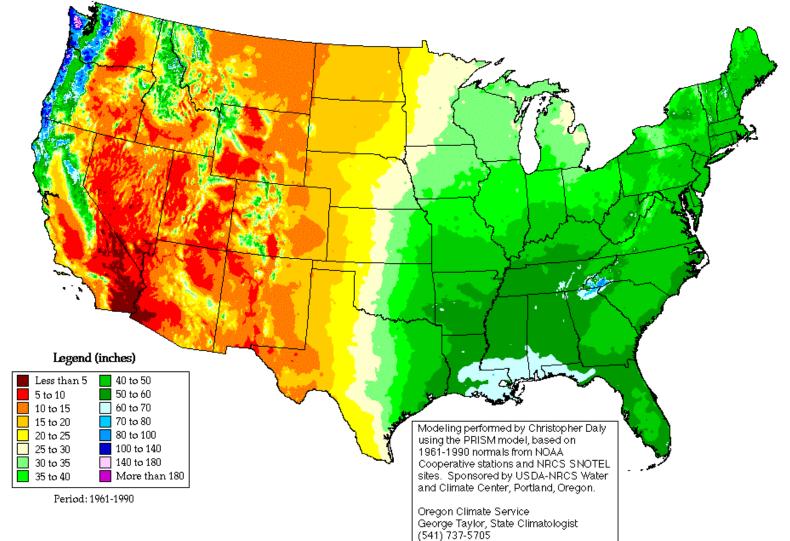
This map is a plot of 1961-1990 annual average precipitation contours from NOAA Cooperative stations and (where appropriate) NRCS SNOTEL stations. Christopher Daly used the PRISM model to generate the gridded estimates from which this map was derived; the modeled grid was approximately 4x4 km latitude/longitude, and was resampled to 2x2 km using a Gaussian filter. Mapping was performed by Jenny Weisburg, Funding was provided by NRCS Water and Climate Center.

12/7/97

Rainfall in United States

Annual Average Precipitation

United States of America



Map of water for leaching from rain

SANFORD AND SELNICK

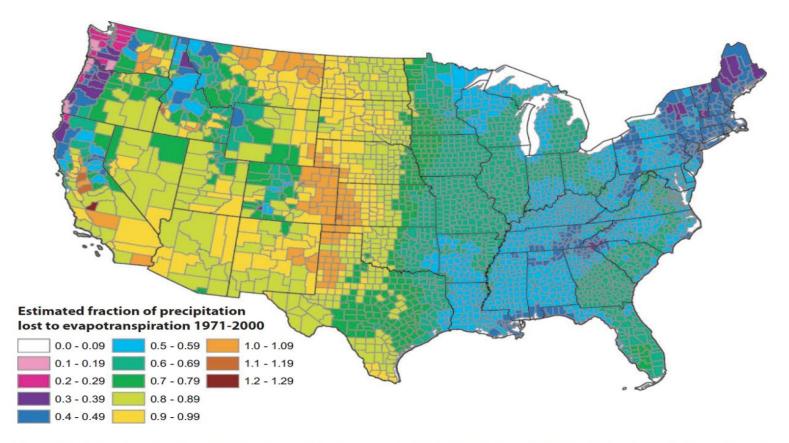


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/P were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.

Leaching rule of thumb

- 6 inches of excess water reduce salinity by 50%
- 12 inches of excess water to reduce salinity by 80%
- 24 inches of excess water to reduce salinity by 90%

Saline Soil Classes based on 1:1 for annual crops

Class	Electrical Conductivity	Productivity	
Non-saline	< 0.5	Not affected	
Very slightly saline	0.6 to 1.0	Sensitive crops affected	
Moderately saline	1.1-2.0	Yields of many crops affected	
Strongly saline	2.1-4.0	Yields of most crops seriously decreased	
Extremely saline	4.1 and higher	Few if any plants growing	

Salt tolerance of Common crops 1:1

Сгор	E.C. 100% yield	E.C. 75% yield	E.C. 50% yield
Barley	1.7	2.7	3.4
Sugarbeets	1.6	2.6	3.3
Corn	1.2	1.5	2.5
Wheat	1.0	1.7	2.3
Flax	0.9	1.3	2.0
Canola	0.9	1.3	2.0
Soybeans	0.8	1.2	1.8
Potatoes	0.8	1.2	1.8
Edible beans	0.6	1.1	1.6

ND Remediation Manual

- Saline soil: A nonsodic soil containing sufficient soluble salts to impair its productivity. The conductivity of the saturation extract is greater than 4 mmhos/cm (at 25°C) and the pH is usually less than 8.3.
- Definition from American Petroleum Institute
- Note, that is level where there is basically no growth

How to monitor saltwater?

- Oil is relatively easy to see and detect.
- Salt is often invisible to the eye, no odor, wouldn't suggest tasting.
- Need the proper tools.

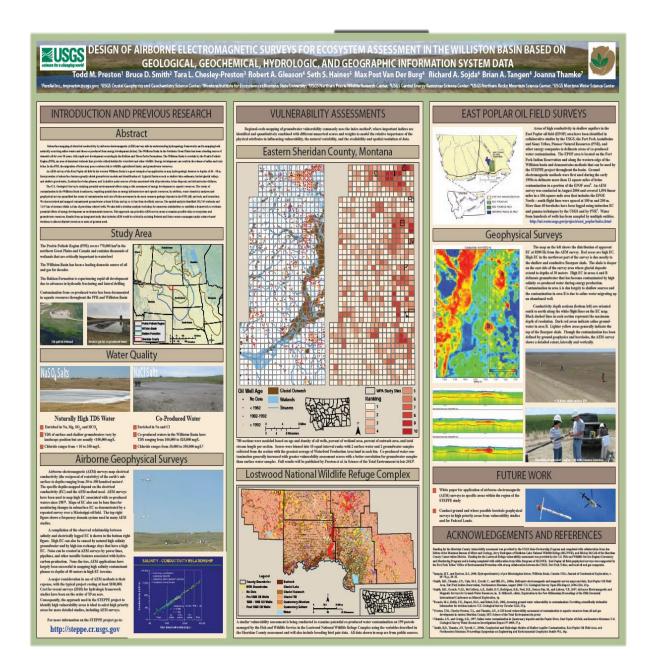


In cooperation with the Office of Environmental Protection of the Fort Peck Tribes

Helicopter Electromagnetic and Magnetic Survey Maps and Data, East Poplar Oil Field Area, Fort Peck Indian Reservation, Northeastern Montana, August 2004

By Bruce D. Smith, Joanna N. Thamke, Michael J. Cain, Christa Tyrrell, and Patricia L. Hill

Done



Airborne Geophysical Surveys

Airborne electromagnetic (AEM) surveys map electrical conductivity (the reciprocal of resistivity) of the earth's subsurface to depths ranging from 30 to 300 hundred meters². The specific depths mapped depend on the electrical conductivity (EC) and the AEM method used. AEM surveys have been used to map high EC associated with co-produced waters since 1987³. Maps of EC also can be base lines for monitoring changes in subsurface EC as demonstrated by a repeated survey over a Mississippi oil field. The top right figure shows a frequency domain system used in many AEM studies.

A compilation of the observed relationship between salinity and electrically logged EC is shown in the bottom right figure. High EC can also be caused by natural high salinity groundwater and by high ion exchange clays that have a high EC. Noise can be created in AEM surveys by power lines, pipelines, and other metallic features associated with hydrocarbon production. None-the-less, AEM applications have largely been successful in mapping high salinity contaminant plumes to depths of 40 meters in high EC terrains.

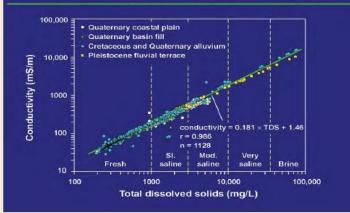
A major consideration in use of AEM methods is their expense, with the typical project costing at least \$100,000. Cost for recent surveys (2010) for hydrologic framework studies have been on the order of \$9 an acre. Consequently, the approach used in the STEPPE project to identify high vulnerability areas is ideal to select high priority areas for more detailed studies, including AEM surveys.

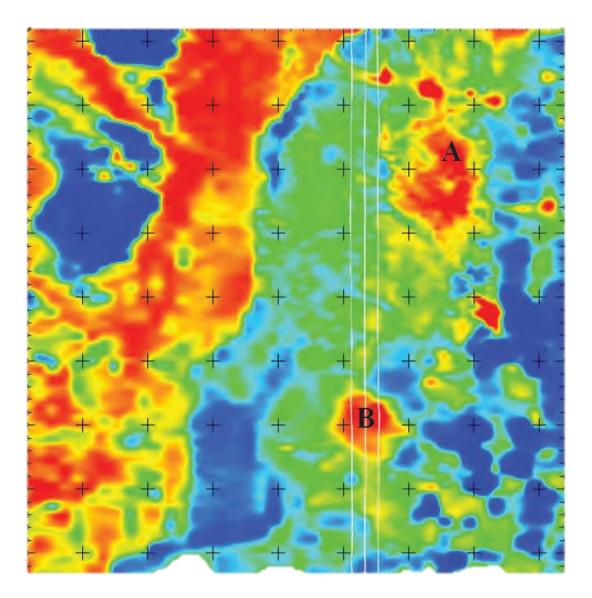
For more information on the STEPPE project go to:

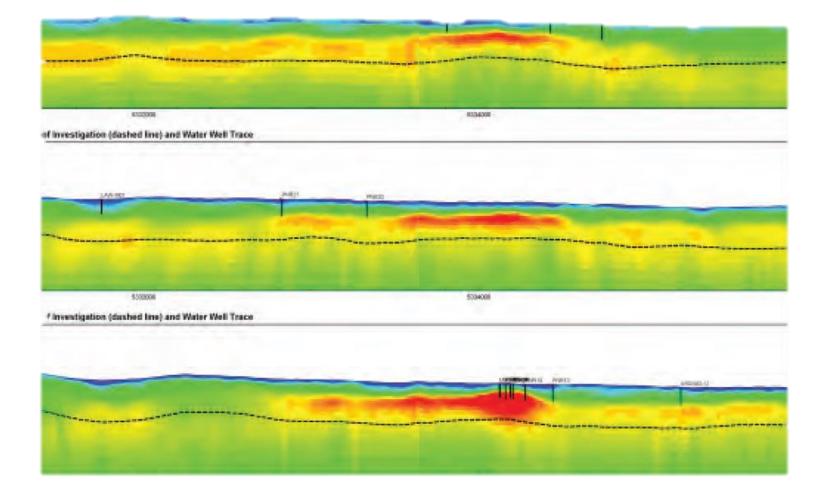
http://steppe.cr.usgs.gov



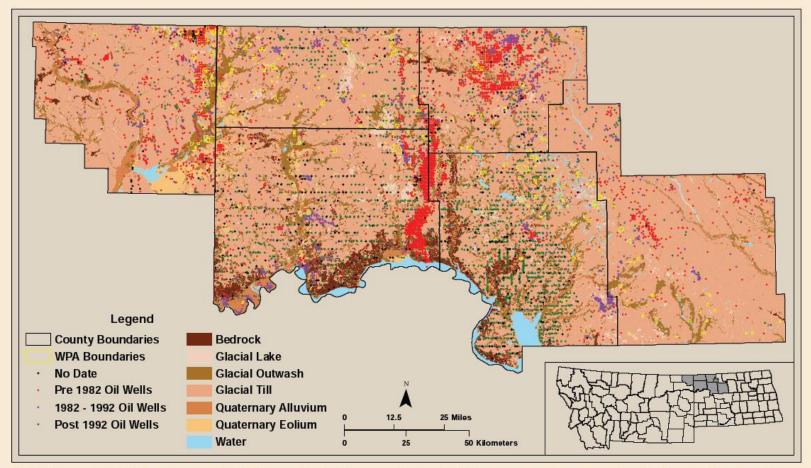
SALINITY - CONDUCTIVITY RELATIONSHIP



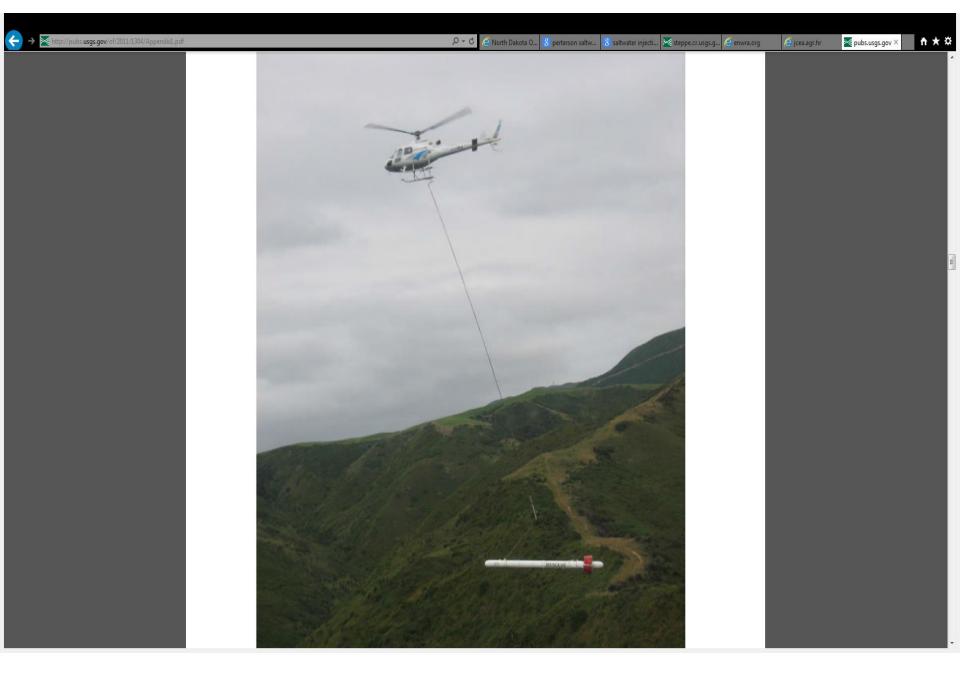




Lostwood National Wildlife Refuge Complex



A similar vulnerability assessment is being conducted to examine potential co-produced water contamination on 199 parcels managed by the Fish and Wildlife Service in the Lostwood National Wildlife Refuge Complex using the variables described in the Sheridan County assessment and will also include breeding bird pair data. All data shown in map are from public sources.





Airplanes too.



Ground based electromagnetic sensors

• Both frequency and time domain available.

• Time domain good for deep, not so good surface.

 Frequency domain good shallow, multiple frequencies allow modeling

EM-31 Single dimensional, up to 6 meter depth



Gem-2 multifrequency



GSSI Profiler 3 freqency



Ohmapper capacitively coupled resistivity meter



TDS, pH meters



Sodium meter



We can use many ways to measure salt

- These just give us a measurable way to track one thing that can hurt crops.
- Bottom line is crop productivity, remediation of damage has not occurred until productivity is restored.
- Issue isn't salt it's the effect of salt on production.

- Remediation manual would work to get some growth of perennial salt tolerant grasses, likely doesn't restore productivity there either, but it looks okay from a distance.
- It isn't working for crop producers.
- Push for hauling out and replacing soil.
- Lenders reluctant to loan on land. Affects ability to buy and sell.
- Huge disincentive to sign easements for pipelines.
- Incentive is to sue. State is not protecting land lawsuits only recourse left to landowners.