MANAGEMENT ZONE DELINEATION TECHNIQUES TO AID IN-SEASON SENSOR BASED NITROGEN APPLICATION

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Abstract

The increased efficiency of nitrogen fertilizer (N) use has been a long-term goal in reduction of nitrate contamination in the state of Nebraska. Preliminary research has shown sensor based in-season application of nitrogen has the ability to be economic and environmentally viable. Although benefits have been published there is an opportunity for increased accuracy of N application through the integration of preprocessed georeferenced management zones. In-season sensor based N application relies on the instantaneous crop canopy health to determine recommendation. Yield potential in not only a factor of crop health but also of soil properties. Using soil electrical conductivity (EC) readings along with landscape attributes allow for a generalized estimation of soil properties and can allow for N recommendations to be based on crop status and yield potential.

Introduction

Groundwater contamination resulting from high levels of nitrate is an increasing concern for the state of Nebraska. The overwhelming cause of nitrate contamination is due to excess nitrogen fertilizer application in agricultural production of corn (Zea mays L.). The U.S. Environmental Protection Agencies (EPA) lists the maximum contaminant level in public drinking water for nitrate-nitrogen at 10 mg/l. In 2008 3,763 wells were tested for nitrate-nitrogen concentrations. 2,440 wells were below 7.5 mg/l, 329 wells were between 7.5-10 mg/l, and 994 wells were above 10 mg/l (NE DEQ, 2009). This survey showed that over 35% of the wells sampled in the state of Nebraska in 2008 were at or exceeded the EPA maximum contaminant level.

One way of decreasing the over application of nitrogen fertilizer (N) by farmers is to increasing the efficiency of nitrogen fertilizer (N) use. This will result in an overall decrease in excess N in the soil and groundwater while maintaining yields and increasing profits. One way to increase the efficiency of N use by corn is to coordinate application of N with demand by the plant, this will likely result in multiple N applications through a growing season.

Active canopy sensors have been developed along with a variety of vegetation indices to measure the canopy N status of corn during V7-V12 growth stages (A. Gitelson et al., 2005 and M.R. Schlemmer et al., 2005). The ability to measure the canopy N status has led the development of algorithms that provide in-season N application recommendations (F. Solari, et al., 2010). One of the limitations of these algorithms is that they base N application rates on one uniform yield potential. Every field to a degree has variations in soil properties, relative elevation, slope, and aspect Yield potential of a field will realistically never be uniform. This variation would likely not be able to be determined through active sensor measurements. This can result in over application or under application of N in a specific area of a given field. Our goal is to develop zones of relative yield potential to allow for an adjustment to the algorithm and increase the precision of application of in-season nitrogen application.

Approach

For this project field scale data was collected at 10 locations over 2 years across the state of Nebraska. Each field location was irrigated using a center pivot system and a uniform application of N fertilizer was applied in accordance to the producer's management strategy. Soils varied throughout the locations, ranging from Valentine fine sand (Mixed, mesic Typic Ustipsamment) to Moody silty clay loam (Fine-silty, mixed, superactive, mesic Udic Haplustoll).

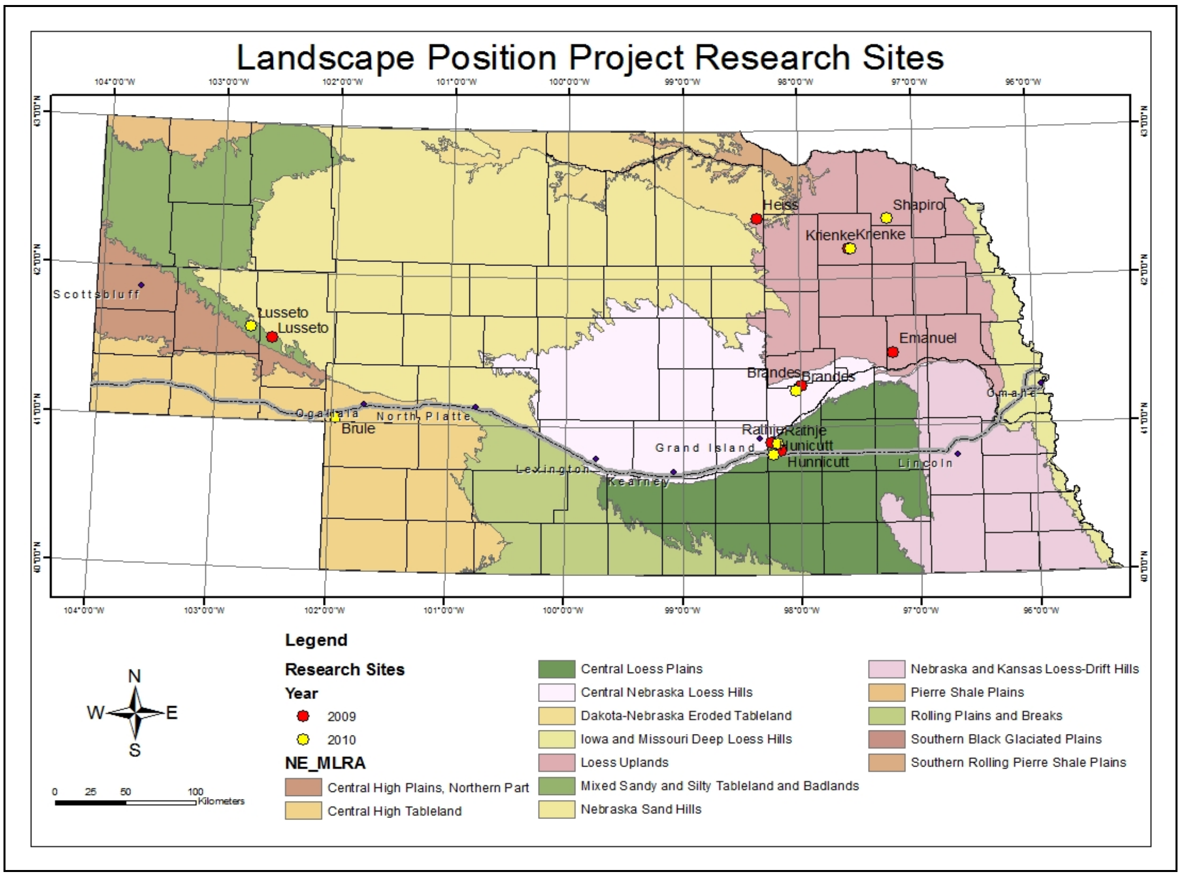

Figure 1: Map of Project Research Sites

Prior to planting, soil electrical conductivity (EC) readings were taken using a Veris 3100 on-the-go soil mapping system. The Veris 3100 system is equipped with a dual depth array. This allowed for measurements to be taken at 0-30cm and 0-91cm simultaneously. This system measures the soil's ability to conduct an electrical charge. Soil EC is sensitive to soil texture, salinity, soil moisture content, and organic matter. With a variety of influences on EC interpretation of maps can be difficult and determining exact influences on EC readings impossible. EC maps do show a relative variability in a field.

A Trimble AgGPS 442 global navigation satellite system (GNSS) receiver with base station was used to provide georeferenced measurements of the soil EC readings. The Trimble AgGPS 442 allows for Real Time Kinematics (RTK). This provides spatial accuracy of < 3cm of soil EC measurements. Along with providing the georeferenced soil EC data the Trimble AgGPS 442 provides elevation at the same spatial accuracy. With the elevation dataset landscape characteristics can be used in development of zone delineation. Relative elevation, % slope, slope curvature, and aspect were extrapolated from the elevation dataset.

The plan is to generate zones using the soil EC measurements and components of measured field elevation. These zones will be created using a variety of combinations of the data layers. The suitability of the zones will be evaluated using georeferenced yield maps. Erdas Imagine and ESRI ArcView 9.3 were used to process all data.

Preliminary Results

Most of the data is still being collected or in the preprocessing stages. The main focus will be to evaluate the accuracy of several different methods of management zone delineation using various combinations of data layers. The first management zone delineation will consist of a combination of shallow and deep soil EC readings separated into 6 classes. The second management zone classification will include % slope and slope curvature divided into 6 classes. The final management zone delineation will be a combination of % slope, slope curvature, and shallow soil EC values separated into 6 classes. One preliminary result compared the yield across the field in each of 3 management zones based solely on shallow soil EC measurements. The following figures show some an initial soil EC classification and corresponding yield data and the spatial distribution of the classifications calculated from the elevation data.

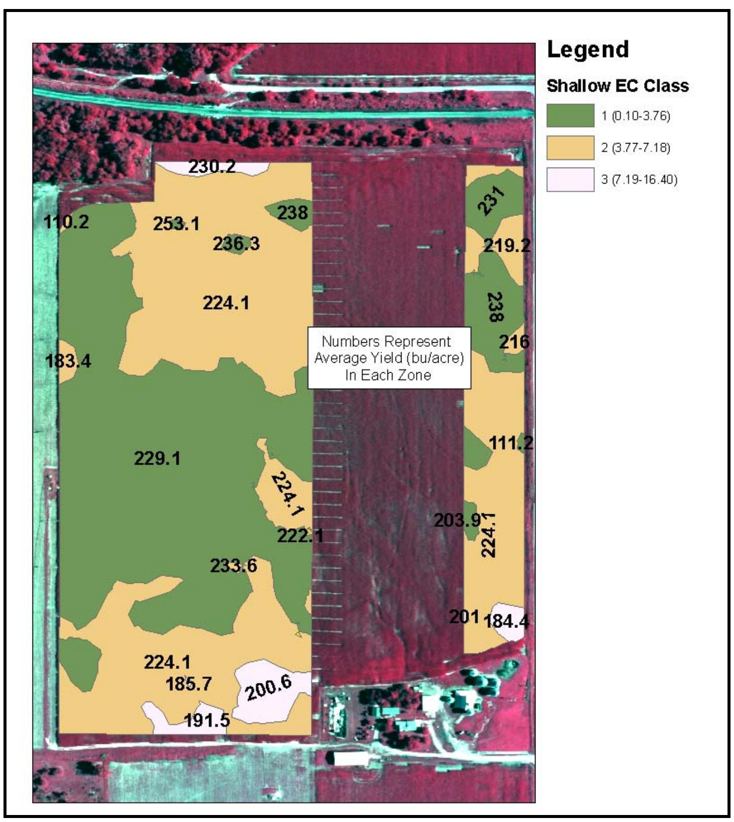

Figure 2: Map of Soil EC zones with average yields.

Management Zone	Join Count	Yield (Bu/acre)
1	7	253.081286
1	147	230.997694
1	25	236.306640
1	334	238.033177
1	23	203.867739
1	3583	229.141032
2	91	219.164121
2	23	216.042739
2	30	183.371233
2	7	233.562571
2	3941	224.052100
3	65	230.201923
3	5	201.045200
3	55	184.401218
3	3	185.705333
3	192	200.572807
3	74	191.465527

Figure 3: Yields separated by zone based on components of Soil EC.

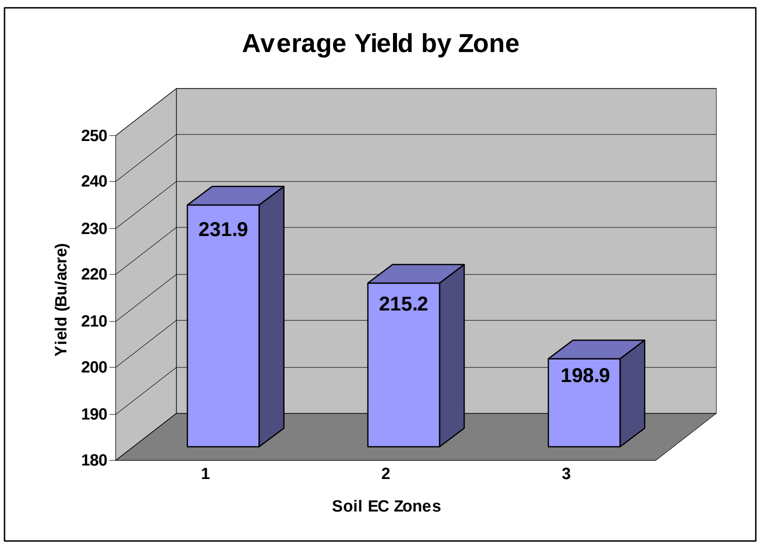

Figure 4: Graph of average yields separated by zone based on components of Soil EC.

The following figures show the measured slope classes derived from the RTK GPS elevation dataset. In figure 5 the NRCS soil survey is overlaid over the % slope class zones. This figure illustrates the variability of % slope within a given soil survey mapping unit. Using this data together with slope type provide a useful representation of landscape position within a field. Figure 6 displays the calculated slope types. The 3 classes are designated as linear, concave, and convex slopes. Slope type will affect erosion and deposition potential of an area of the field. The following landscape position zones were created on a site in the 2010 growing season and yield data is not currently available for comparison.

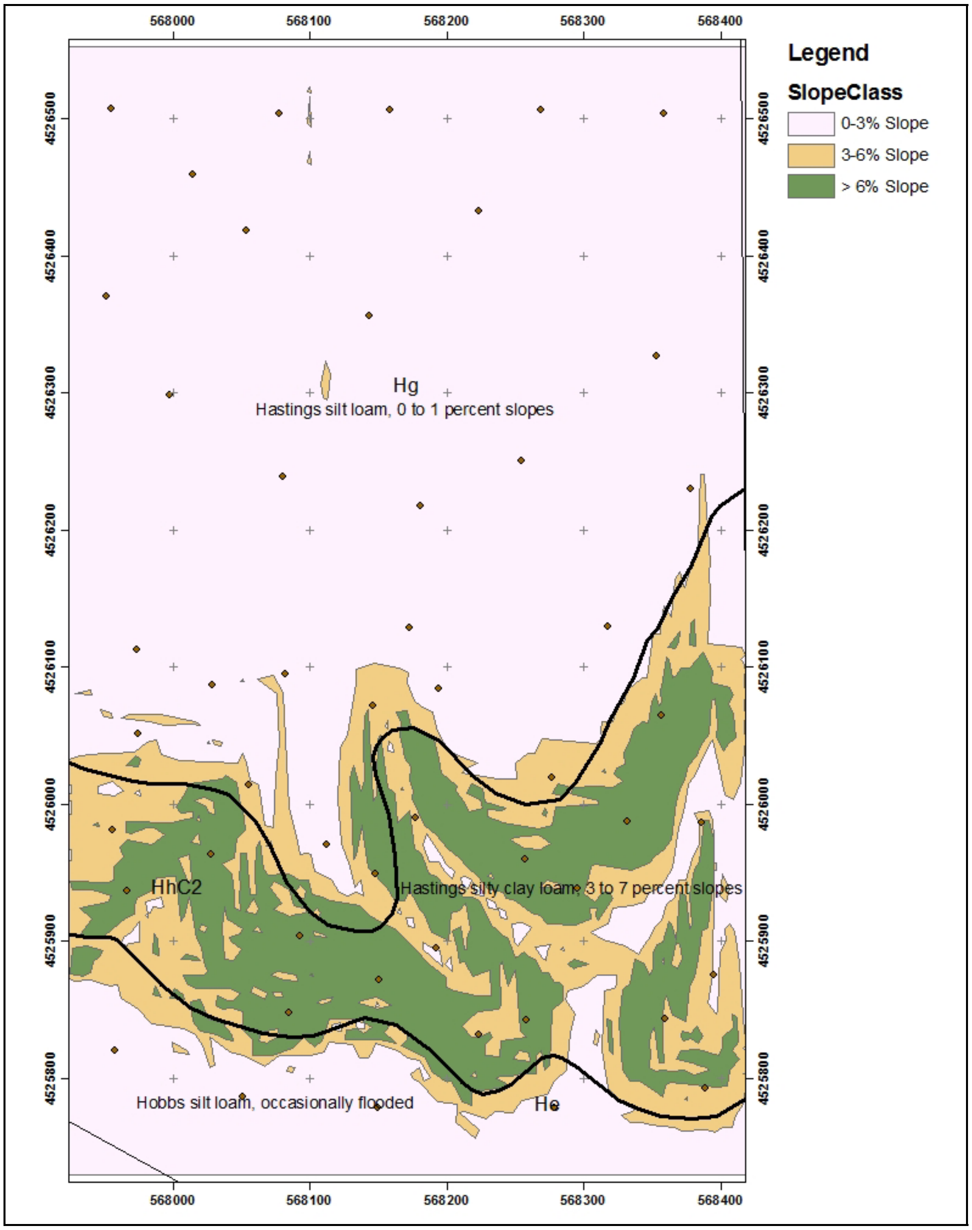

Figure 5: Map of slope class with NRCS soil survey overlay.

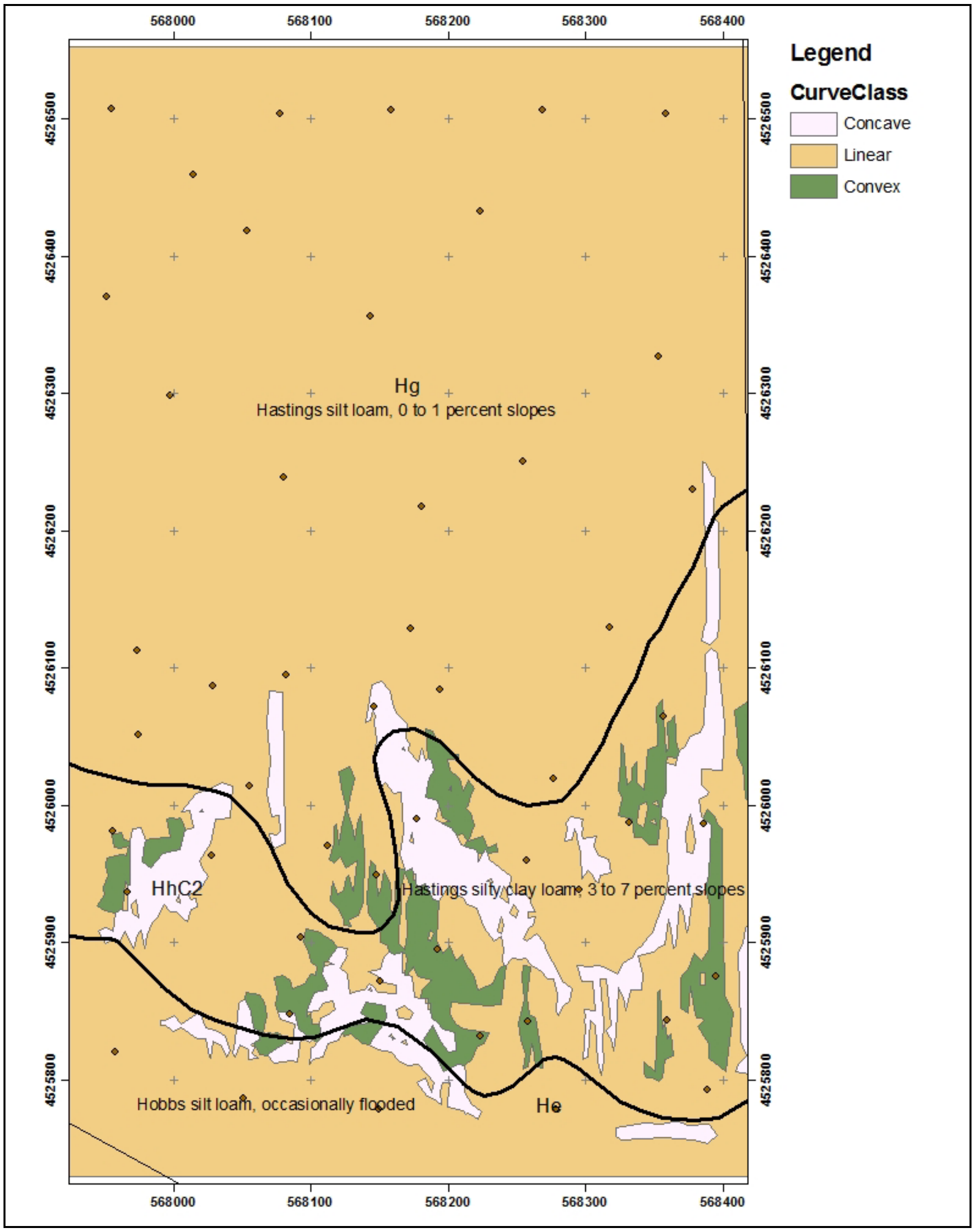

Fig. 6: Map of slope type with NRCS soil survey overlay.

Summary

Pre-plant soil EC measurements in conjunction with high spatial resolution elevation measurements have the potential to provide useful ancillary data for in-season nitrogen management. The management zones hold the potential to account for some measure of in-field variability. Further comparisons across the entire collection of site-years are required but initial results show promise.

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