United States Department of Agriculture

NRCS

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SUBJECT: SOI – Geophysical Assistance

May 7, 2015

TO: Ivan Dozier
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USDA-Natural Resources Conservation Service
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File Code: 330-7

Purpose:
To conduct electromagnetic inductions (EMI) surveys in support of various field studies being carried out in central Illinois.

Participants:
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Dan Withers, Cartographic Technician, USDA-NRCS, Champaign, IL
Marc Zucco, Resource Soil Scientist, USDA-NRCS, Springfield, IL

Activities:
All activities were completed during the period of April 21 to 23 2015.

Summary:

1. Between June 1990 and April 2015, Jim Doolittle participated in 30 field assistance projects in Illinois. Jim is deeply grateful to the SCS and NRCS personnel who worked with and assisted him on these projects, and shared fellowship in the field. Knowledge has been gained from these investigations and several papers written documenting these experiences. This is Jim's last trip as a NRCS employee to Illinois. He wishes you and your staff "Fair Winds and Following Seas".

2. At two sites in Morgan County, EMI provided no indication of nitrate levels or distribution patterns within fields. However, this was not unexpected, as nitrogen is applied and dispersed across entire fields rather than being concentrated at point sources. This study did suggest that under favorable soil moisture conditions, EMI may be a suitable tool to detect buried agricultural drainage tiles.

3. At two *Prairie Hill* ecological sites in Mason County, EMI was used to separate areas of coarse-silty from sandy soils. Soil texture is strongly correlated with soil moisture, and the viability of different sites for diverse plant communities. Spatial EMI data appears to provide an innovative and helpful resource for interpreting some ecosystem patterns. As evident in this study, EMI

offers insight into the distribution and patterns of soil properties and vegetation that are subtle and difficult to interpret using traditional surveying techniques.

4. High-intensity EMI surveys improved the depiction of soils that differ in drainage and form hydrosequences on two different landscapes in McLean and Piatt Counties.

/s/ Jonathan W. Hempel

JONATHAN W. HEMPEL

Director

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Technical Report on Geophysical Investigations conducted in Illinois on April 21 to 23, 2015

James A. Doolittle

Background:

Nitrate Study – Morgan County:

In most agricultural areas of Illinois, tile drains have been installed to reduce soil moisture and runoff, and allow production of crops. These drains act as conduits for applied chemicals and are known to have highly variable nitrate concentrations during major precipitation events or droughts. Large and rapid nitrogen fluxes have been observed in the surface water and groundwater of Illinois. These fluxes have prompted the USGS to deploy a number of continuous monitoring nitrate sensors in several watersheds (Fox River, Indian Creek, East Bureau Creek, Spoon River, Kickapoo Creek, and Illinois River). In this study, the use of electromagnetic induction (EMI) to assess NO_3-N in agricultural fields was explored at two sites in Morgan County.

Electromagnetic induction measures the bulk or apparent electrical conductivity (EC_a) of soils. Apparent electrical conductivity is a depth-weighted, average conductivity measurement for a column of earthen materials to a specific depth (Greenhouse and Slaine, 1983). Variations in EC_a are produced by changes in the electrical conductivity of earthen materials. Apparent electrical conductivity will increase with increases in soluble salt, water, and clay contents, and temperature (McNeill, 1980). Across agricultural fields, differences in soil moisture and texture are known to exert a larger influence on EC_a than small differences in nutrient concentrations (Heiniger *et al*., 2003). Nevertheless, Wienhold and Doran (2008) obtained a high correlation ($r^2 = 0.81$) between EC_a and NO_3-N in a cultivated field in Nebraska. However, the relationship measured by Wienhold and Doran (2008) was negative, with areas of high EC\ having low NO_3-N levels. Variations in soil texture and moisture affect NO_3–N accumulation and loss. Finer-textured soils have slower drainage and greater potential for denitrification than medium and coarser-textured soils. As a result, Cockx *et al*. (2005) and Heiniger *et al.* (2003) showed that EMI can be used to delineate zones with different nutrient levels and risks of NO3 − losses. Eigenberg *et al.* (2002) observed that EMI measurements can provide insight into the dynamics of available N transformations and may serve as a useful indicator of available N in soils.

Ecological Site Assessments – Mason County:

Geophysical methods are being increasingly used in ecological site assessments (Jayawickreme *et al*., 2013; Robinson *et al*. 2008; Stroh *et al*., 2001). Electromagnetic induction was also used to separate coarse-silty from sandy soils on dry *Prairie Hill* ecological sites in Mason County. Separation of a *Prairie Hill* ecological site into community types is based primarily on landform and substrate characteristics that influence moisture gradients and species composition. In this study, EMI was used as rapid reconnaissance tool to provide high-intensity maps at two *Prairie Hill* ecological sites in Mason County.

Soil Variability Studies –McLean and Piatt Counties:

Growing concerns over the sustainability of the environment have focused increased attention on the flow of water and the fate of nutrients and contaminants in soils at different spatial and temporal scales (Pachepsky *et al*., 2008; Brevik *et al*., 2015). At field and landscape scales, soil properties and hydrological processes are exceedingly complex, interconnected, and variable; they are therefore difficult to characterize and map (Pachepsky *et al*., 2008). Soil surveys provide some order to this complexity and variability, but are static and do not adequately address the dynamic nature of hydrological processes and functioning across scales (Bouma *et al*., 2011).

Electromagnetic induction can be used as a exploration tool to confirm acquired knowledge, identify areas of anomalous or unanticipated spatial EC_a patterns, provide guides for the placement of soil boundary lines, and identify the 'best' locations for supportive sampling and/or monitoring. Studies were completed in McLean and Piatt Counties to further demonstrate the efficiency of EC_a data to provide inferences into soil structure and hydrological processes and functions.

Equipment:
An EM38-MK2 meter (manufactured by Geonics Limited, Mississauga, Ontario) was used in this study. [1] Operating procedures for the EM38-MK2 meter are described by Geonics Limited (2009). The EM38-MK2 meter operates at a frequency of 14.5 kHz and weighs about 11.9 lbs. The meter has one transmitter coil and two receiver coils, which are separated from the transmitter coil at distances of 1.0 and 0.5 m. This configuration provides two nominal exploration depths of 1.5 and 0.75 m when the meter is held in the vertical dipole orientation (VDO), and 0.75 and 0.40 m when the meter is held in the horizontal dipole orientation (HDO). The meter measures the bulk or apparent electrical conductivity (EC_a) of soils, which is expressed in milliSiemens/meter (mS/m). In this study, EC_a data were not corrected to a standard temperature of 75^{o} F.

Figure 1 Marc Zucco (Resource Soil Scientist, Springfield, IL) calibrates the EM38-MK2 meter prior to conducting a survey of nitrate levels in a cultivated field in Morgan County.

A Pathfinder ProXT GPS receiver (Trimble, Sunnyvale, CA) was used to georeferenced the EMI data collected with the EM38-MK2 meter. [1] Position data were recorded at a rate of two reading per second.

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

The Geonics DAS70 Data Acquisition System was used with the EM38-MK2 meter to record and store both EC_a and GPS data. The acquisition system consists of an EMI meter, GPS receiver, and an Allegro CX field computer (Juniper Systems, Logan, Utah).[2] The RTmap38-MK2 software program developed by Geomar Software Inc. (Mississauga, Ontario) was used with the EM38-MK2 meter and the Allegro CX field computer to record, store, and process EC_a and GPS data. [2]

To help summarize the results of the EMI surveys, SURFER for Windows (version 10.0), developed by Golden Software, Inc. (Golden, CO), was used to construct the simulations shown in this report.[2] Grids of EMI data were produced using kriging methods with an octant search.

Survey procedures:
Pedestrian surveys were conducted across each site with the EM38-MK2 meter. The meter was operated in the deeper-sensing VDO with its long axis orientated parallel with the direction of travel. Data were recorded at a rate of two measurements per second.

Study Sites:
<u>Nitrate Study – Morgan County:</u>
Site #1 - Green Road:
This site is located along a field boundary that separates two cultivated fields in Morgan County. The fields are located off of Literberry-Tiopic Road about 1.4 miles north of Concord. The concentration of nitrates that is leaving one field is being measured by the USGS. The site is located in areas of Virden silty clay loam, 0 to 2 percent slopes (50A) and Ipava silt loam, 0 to 2 percent slopes (43A). The very deep, poorly drained Virden (fine, smectitic, mesic Vertic Argiaquolls) and somewhat poorly drained Ipava (fine, smectitic, mesic Aquic Argiudolls) soils formed in loess on till plains.

Site #2 - Home Site:
This site is located across adjoining cultivated fields that spans a waterway. The fields are located off of Concord-Arenzville Road about 1.2 miles south of Concord. The site contains delineations of Sylvan silt loam, 10 to 18 percent slopes, eroded (19D2); Ipava silt loam, 0 to 2 percent slopes (43A); Osco silt loam, 0 to 5 percent slopes (86B); Rozetta silt loam, 2 to 5 percent slopes; (279B); and Elkhart silt loam, 5 to 10 percent slopes, eroded (567C2). The very deep, well drained Sylvan (fine-silty, mixed, superactive, mesic Typic Hapludalfs), Osco (fine-silty, mixed, superactive, mesic Typic Argiudolls), Rozetta (fine-silty, mixed, superactive, mesic Typic Hapludalfs), and Elkart (fine-silty, mixed, superactive, mesic Typic Argiudolls) soils form in loess on loess covered till plains. Osco and Elkart soils have a mollic epipedon. Depth to carbonates is less than 40 inches for Sylvan and Elkart soils. Depth to carbonates is greater than 40 inches for Ipava, Sylvan, and Osco soils. In addition, Ipava soils contain more clay.

<u>Ecological Site Assessment – Mason County:</u>
Site #3 - Revis Hill Prairie:
Site #3 is located off of East Revis Bluff Road, on a bluff that overlooks the Sangamon River floodplain about 5.5 miles south of Easton and 7.2 miles northwest of Greenview in Mason County. The site is located in an area of idle land and a large delineation of Hamburg silt loam, 35 to 60 percent slopes (30G). The very deep, somewhat excessively drained Hamburg (coarse-silty, mixed, superactive, calcareous, mesic Typic Udorthents) soils form in calcareous loess on uplands.

Site #4 - Manito Sand Prairie:
Site #4 is located off of 2900 East Road about 1.8 miles southwest of Manito in Mason County. The site is located in an area of idle land and includes delineations of Plainfield sand, 1 to 7 percent slopes (54B); Sparta loamy sand, 1 to 6 percent slopes (88B); and Onarga sandy loam, 2 to 5 percent slopes (150B).

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

The very deep, excessively drained Plainfield (mixed, mesic Typic Udipsamments) and Sparta (sandy, mixed, mesic Entic Hapludolls) soils and the well-drained Onarga (coarse-loamy, mixed, superactive, mesic Typic Argiudolls) form in sandy drift on outwash plains. Both Sparta and Onarga soils have mollic epipedons. The Onarga soil contains more clay (about 12 and 18 percent in control section).

Soil Variability Studies –McLean and Piatt Counties

Site #5 - Lake Bloomington Trib (McLean County):

Site #5 is located off of N1300 East Road just south of Evergreen Lake and about 1.9 miles west-northwest of Hudson in McLean County. The site is located in a cultivated field having delineations of Lisbon silt loam, 0 to 2 percent slopes (59A); La Rose silt loam, 10 to 18 percent slopes, eroded (60D2); Clare silt loam, 0 to 2 percent slopes (663A); and Radford silt loam, 0 to 2 percent slopes, occasionally flooded (8074A). The very deep, somewhat poorly drained Lisbon (fine-silty, mixed, superactive, mesic Aquic Argiudolls) soils form in loess or other silty material and in the underlying loamy till on till plains. The very deep, well drained La Rose (fine-loamy, mixed, active, mesic Typic Argiudolls) soils form in loamy till on uplands. The very deep, moderately well drained Clare (fine-silty, mixed, superactive, mesic Oxyaquic Argiudolls) soils form in loess or other silty material and the underlying loamy stratified materials on stream terraces. The very deep, somewhat poorly drained Radford (fine-silty, mixed, superactive, mesic Fluvaquentic Hapludolls) soils form in recent silty alluvium on flood plains.

Site #6 - 4-H Camp (Piatt County):

Site #6 is located at the 4-H Club camp in Piatt County. The site is located in a cultivated field about 4.1 miles south-southwest of Monticello. The site includes delineations of Drummer silty clay loam, 0 to 2 percent slopes (152A); Elburn silt loam, 0 to 2 percent slopes (198A); and Plano silt loam, 0 to 2 percent slopes, eroded (199B2). This hydrosequence consists of very deep, poorly drained Drummer (fine-silty, mixed, superactive, mesic Typic Endoaquolls), somewhat poorly drained Elburn (fine-silty, mixed, superactive, mesic Aquic Argiudolls), and well drained Plano (fine-silty, mixed, superactive, mesic Typic Argiudolls) soils that form in loess or other silty material and in the underlying loamy stratified outwash on nearly level outwash and till plains.

Results:

Site #1 - *Green Road*:

Figure 2 contains two two-dimensional (2D) maps of the *Green Road* study site showing the spatial distribution of EC_a in the upper 0 to 75 cm (map on left) and upper 0 to 150 cm (map on right) of soil profiles. The white-colored vertical line in the middle of each plot represents the field boundary separating two units of management. On each of these maps the soil boundary line has been imported from the Web Soil Survey.[3] This boundary line separates areas of Virden silty clay loam, 0 to 2 percent slopes (50A) from Ipava silt loam, 0 to 2 percent slopes (43A).

A comparison of the two maps in Figure 2 indicates that EC_a increases with increasing depth. This trend is associated with increased moisture and clay content at lower soil depths in both Ipava and Virden soils. Based on 6659 measurements, for the 0 to 75 cm depth interval, EC_a averaged 27.8 mS/m with a range of 1.2 to 86.6 mS/m. For the 0 to 150 cm depth interval, EC_a averaged 40.1 mS/m with a range of 27.9 to 59.5 mS/m.

Electromagnetic induction provides no indication of nitrate levels or distribution patterns within these fields. This was not an unexpected results as nitrogen is applied and dispersed across the entire fields rather than being concentrated at a point source. At this time of the year (early spring), the moisture

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[3] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [04/28/2015].

content in these soils is relatively high. High moisture level appears advantageous for the detection of buried agricultural drainage tiles. While not confirmed, linear patterns of higher EC_a that cross the two fields in the deeper, 0 to 150 cm map (Figure 2, right) suggest the possible presence of older drainage tile systems. These patterns of higher EC_a are associated with higher soil moisture contents near drainage tiles. In Figure 2, several spatial patterns of higher EC_a, which appear to suggest buried drainage tiles, have been highlighted with black-colored segments lines. The two black-colored arrows shown in Figure 2 identify spatial EC_a patterns that may represent laterals. If the presence of these tiles can be confirmed, this finding may impact the conclusions drawn from the continuous monitoring nitrate sensor installed by the USGS.

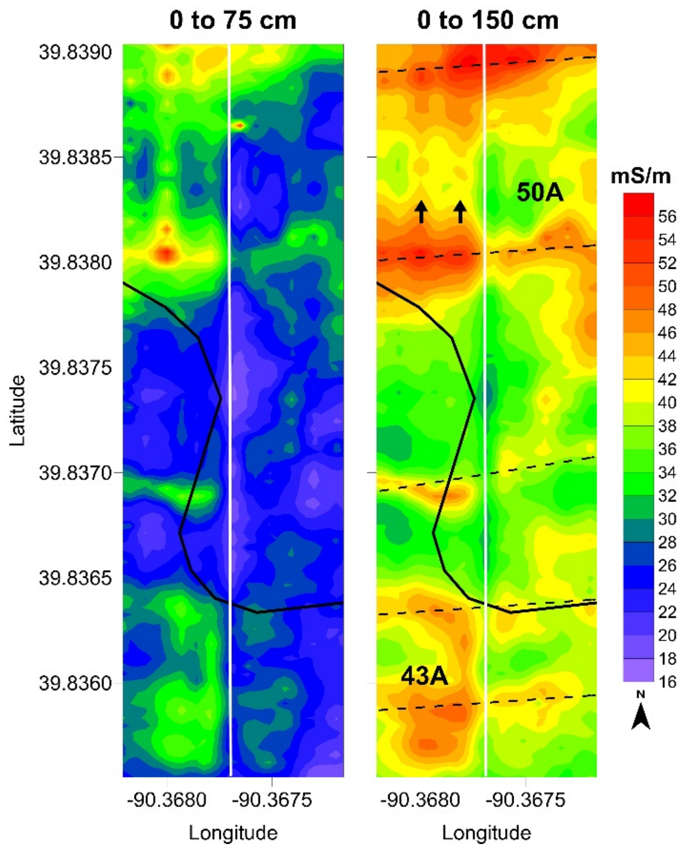

Figure 2 These maps show the distribution of EC_a measured across the *Green Road* site in Morgan County for the upper 75 (left) and 150 (right) cm of the soil profiles. The soil boundary line and map unit symbols (right-hand map only) have been imported from the Web Soil Survey.

<u>Site #2 - *Home Site*:</u>

Figure 3 contains two 2D maps of the *Home Site* study sites showing the spatial distribution of EC_a in the upper 0 to 75 cm (map on left) and upper 0 to 150 cm (map on right) of soil profiles.. On these maps, the soil boundary lines and map unit symbols (only on left-hand map) were imported from the Web Soil Survey.[4]

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[4] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [04/28/2015].

Compared with the *Green Road* site, the *Home Site* has greater relief, and the soils are better drained (well drained versus poorly and somewhat poorly drained) and contain less clay (fine-silty versus fine textured). These factors result in the *Home Site* having a lower average EC_a than the *Green Road* site. At the *Home Site*, based on 4541 measurements, for the 0 to 75 cm depth interval, EC_a averaged 20.1 mS/m with a range of -9.8 to 165.0 mS/m. For the 0 to 150 cm depth interval, EC_a averaged 34.6 mS/m with a range of -4.4 to 125.9 mS/m. However, one-half of the EC_a measurements were between 17.4 and 22.5 mS/m, and between 31.7 and 37.2 mS/m for the 0 to 75 cm and the 0 to 150 cm depth intervals, respectively. The extreme range in EC_a was attribute to a few metallic objects scattered across the site. These features produced anomalously high and low EC_a measurements (in Figure 3, see anomalously high and low EC_a ("A", colored red and purple, respectively) in the southwest portion of the site).

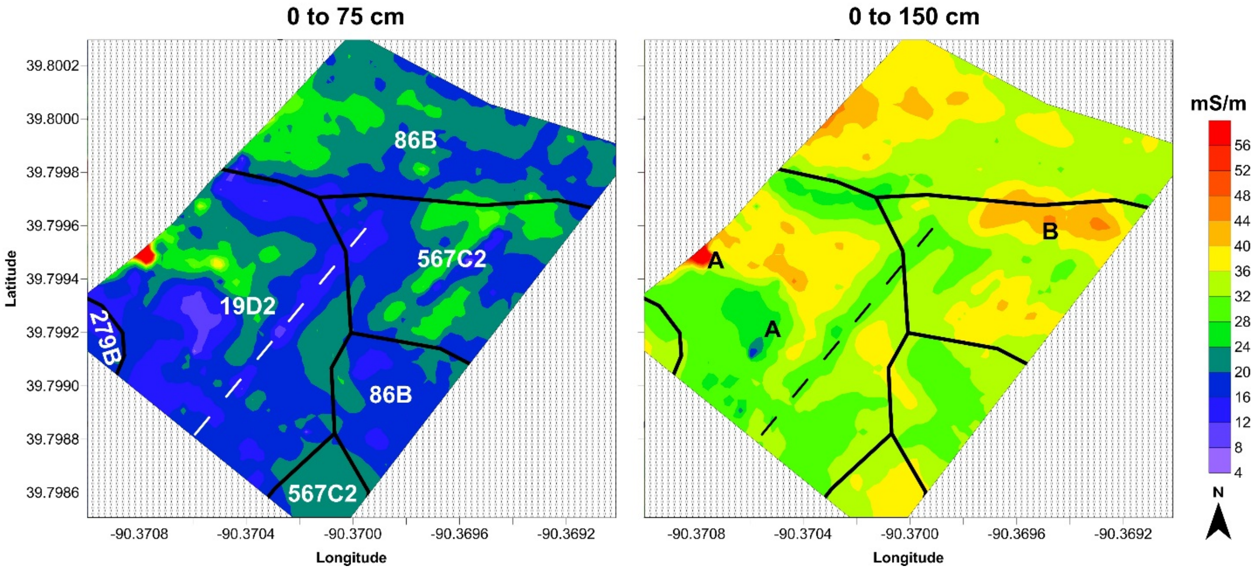

Figure 3. These maps show the distribution of ECa measured across the *Home Site* in Morgan County for the upper 75 (left) and 150 (right) cm of the soil profiles. Soil boundary lines and map unit symbols (left-hand map only) have been imported from the Web Soil Survey.

In Figure 3, the segment line shown on each of the maps approximates the location of a buried agricultural drainage tile within a drainageway. In general, EC_a is low within the drainageways at this site. This contrast with the findings from the *Green Road* site where EC_a was generally higher in lower-lying slope concavities. An exception occurs near "B" (in the right-hand map) in Figure 3. Here, an area of higher EC_a occurs along a lower-lying swale.

At this site, as at the *Green Road* site, EC_a increases with increasing soil depth. Areas of higher EC_a (colored yellow and orange) occur on higher-lying, more stable summit areas. Though drier, these areas typically have greater clay contents nearer the soil surface. Spatial patterns evident in Figure 3 are believed to represent mostly difference in clay and moisture contents and the presence of metallic artifacts scattered across the site. Detailed sampling would be needed to establish whether any relationship exists between NO_3-N levels and EC_a. No inferences on this relationship, if it exists, can be drawn from the maps in Figure 3 alone.

Site #3 - *Revis Hill Prairie*:
Figure 4 contains two three-dimensional (3D) images with overlaid 2D EC_a maps of the *Revis Hill Prairie* study sites. The spatial distribution of EC_a in the upper 0 to 75 cm and upper 0 to 150 cm of soil profiles are shown on the left-hand and right-hand images, respectively. No soil boundary lines or symbols are shown on these images as the study area was entirely within a delineation of Hamburg silt loam, 35 to 60 percent slopes (30G). Relief is about 8 m within this site.

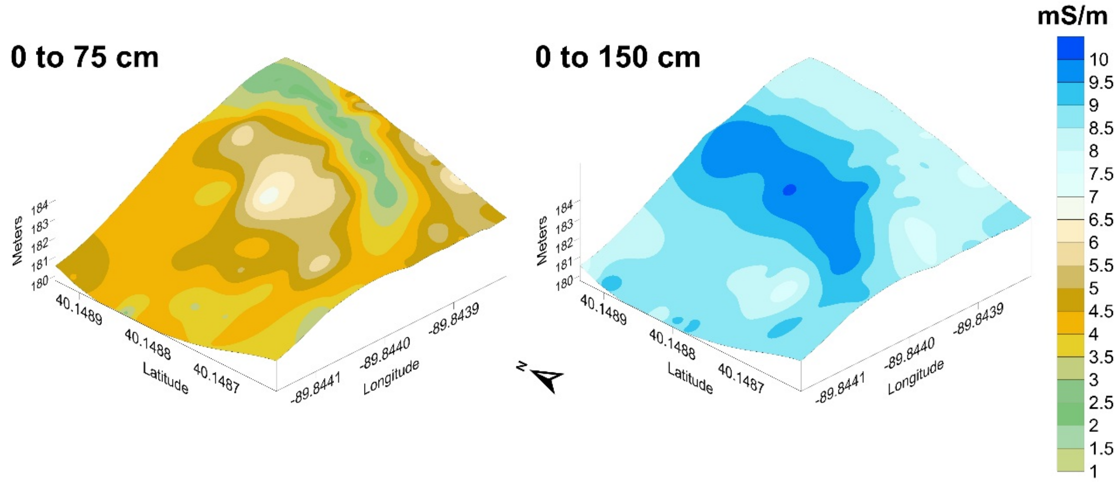

Figure 4. These 3D images show the distribution of EC_a measured across the Revis Hill Prairie site in Mason County for the upper 75 (left) and 150 (right) cm of the soil profiles.

The low clay and moisture contents of Hamburg soils result in very low and relatively invariable EC_a at *Revis Hill Prairie* site. At the *Revis Hill Prairie* site, based on 102 measurements, for the 0 to 75 cm depth interval, EC_a averaged 7.1 mS/m with a range of 1.8 to 7.1 mS/m. For the 0 to 150 cm depth interval, EC_a averaged 8.6 mS/m with a range of 7.5 to 10.1 mS/m.

The objective of this study was to determine whether a link could be observed between EC_a, used as an indicator of variations in soil texture and moisture, and the spatial distribution of plant communities. Casual probings made at this site, confirm that EC_a can be used to separate areas of coarse-silty from sandy soils. Soil texture is strongly associated with soil moisture, and the viability of different sites for diverse plant communities. As evident in the 3D images shown in Figure 4, sandy soils with very low EC_a occupy the ridgeline areas. On concave-concave slopes, immediately below the ridgeline and area of higher EC_a is evident. This areas has coarse-silty soils with suspected higher moisture contents, which are attributed to landscape position and hydrologic processes. At this site, EMI offers insight into the distribution and patterns of soil properties and changes in soils and vegetation patterns that are too subtle and difficult to interpret using traditional surveying techniques.

<u>#4 - *Manito Sand Prairie*:</u>
Figure 5 contains two three-dimensional (3D) images with overlaid 2D EC_a maps of the *Manito Sand Prairie* study sites. The spatial distribution of EC_a in the upper 0 to 75 cm and upper 0 to 150 cm of soil profiles are shown on the left-hand and right- hand images, respectively. On these maps, the soil boundary lines and map unit symbols (map on left) were imported from the Web Soil Survey.[5]

At *Manito Sand Prairie* site, the low clay and moisture contents of Plainfield, Sparta, and Onarga soils result in very low and relatively invariable EC_a. In general, EC_a increased and became slightly less variable with increasing depth of exploration. At the *Manito Sand Prairie* site, based on 1151 measurements, for the 0 to 75 cm depth interval, EC_a averaged 2.5 mS/m with a range of 0.1 to 5.0 mS/m. For the 0 to 150 cm depth interval, EC_a averaged 4.7 mS/m with a range of 3.4 to 5.9 mS/m. These values are all lower and less variable than those recorded in an area of Hamburg soils at the *Revis Hill Prairie* study site.

[5] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [04/28/2015].

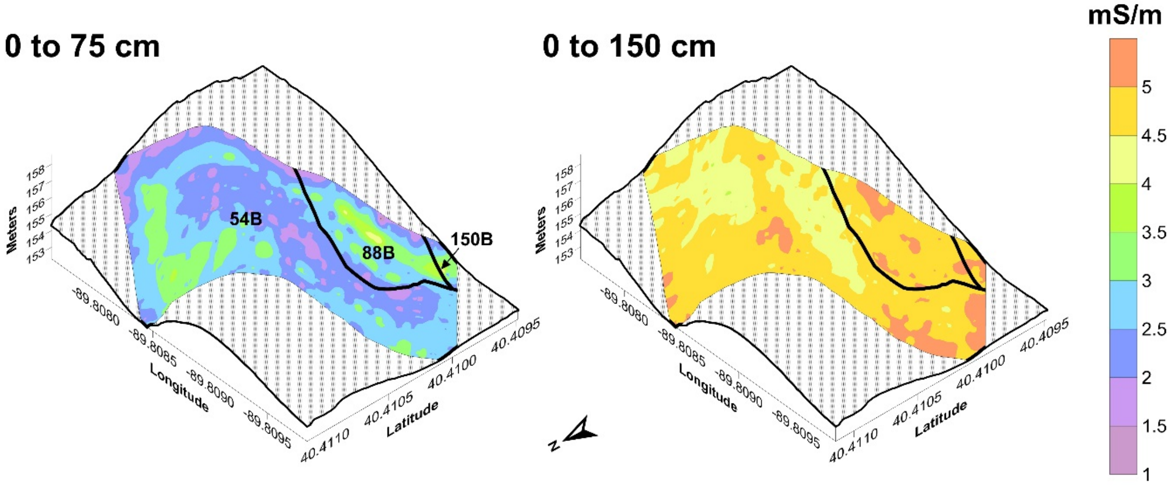

Figure 5. These 3D images show the distribution of EC_a measured across the *Manito Sand Prairie* site in Morgan County for the upper 75 (left) and 150 (right) cm of the soil profiles. Soil boundary lines and map unit symbols (left-hand map only) have been imported from the Web Soil Survey.

As evident in the 3D images shown in Figure 5, spatial EC_a patterns tend to cross rather than conform to the landscape. In general, areas of higher and lower EC_a are associated with lower and higher-lying landscape positions, respectively. However, the linear EC_a patterns, which extend in a general northeast to southwest direction across this site, may suggest deposition patterns of slightly coarse or finer textured materials.

Site #5 - Lake Bloomington Trib:

Figure 6 contains two 3D images with overlaid 2D EC_a maps of the *Lake Bloomington Trib* study site. The spatial distribution of EC_a in the upper 0 to 75 cm and upper 0 to 150 cm of the soil profiles are shown on the left-hand and right-hand images, respectively. On these maps, the soil boundary lines and map unit symbols (map on left only) were imported from the Web Soil Survey.[6]

At the *Lake Bloomington Trib* site, based on 1976 measurements, for the 0 to 75 cm depth interval, EC_a averaged 18.8 mS/m with a range of -30.6 to 41.1 mS/m. For the 0 to 150 cm depth interval, EC_a averaged 27.4 mS/m with a range of 3.8 to 47.8 mS/m.

As evident in Figure 6, spatial EC_a patterns do not conform to soil map unit patterns. Compared with the soil delineations, the EC_a patterns appear to reflect the topography and landform better. This relationship between EC_a and landform is best expressed in Figure 6 on the image to the right, which shows the deeper exploration depth. Areas of lower EC_a are associated with the higher-lying upland area that are dominated by very deep, well drained La Rose and moderately well drained Clare soils. Areas of higher EC_a are associated with lower-lying areas of very deep, somewhat poorly drained Lisbon and Radford soils.

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[6] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [04/28/2015].

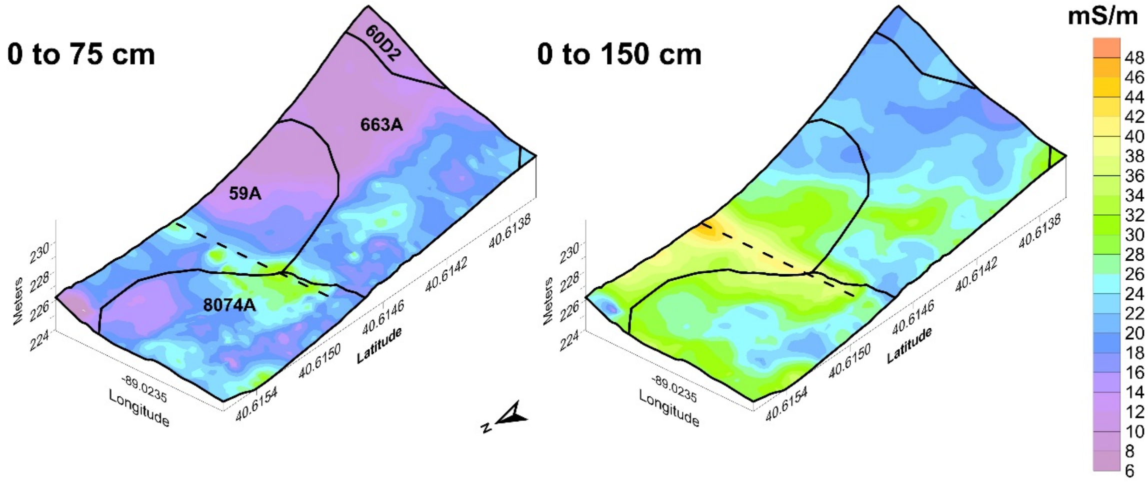

Figure 6. These 3D images show the distribution of EC_a measured across the Lake Bloomington Trib site in McLean County for the upper 75 (left) and 150 (right) cm of the soil profiles. Soil boundary lines and map unit symbols have been imported from the Web Soil Survey.

In Figure 6, a black-colored segmented line has been drawn to identify the location of a verified buried agricultural drainage line. Along this line, the higher EC_a is associated with increased moisture levels.

Site #6 - *4-H Camp Site*:
Figure 7 contains two 3D images with overlaid 2D EC_a maps of the *4-H Camp* study site. The spatial distributions of EC_a in the upper 0 to 75 cm and upper 0 to 150 cm of the soil profiles are shown on the left- and right-hand images, respectively. On these maps, the soil boundary lines and map unit symbols (image on left only) were imported from the Web Soil Survey.[7] The three recognized soils (Drummer, Elburn, and Plano) at this site are all very deep, have a fine-silty control texture, and form in loess or other silty material and in the underlying loamy stratified outwash. The soils differ in drainage and form a hydrosequence on this nearly level landscape. On this landscape, a regular sequence of profiles can be observed in passing from dry to wet conditions (Plano to Elburn to Drummer). A rhythmic pattern of soils differing in drainage characteristics (runoff, permeability, and internal soil drainage) is clearly expressed in Figure 7 as EC_a increases from the well-drained Plano soils to the poorly-drained Drummer soils.

Apparent conductivity was spatially and depth variable across this site. In general, EC_a increased with increasing depth of observation and from east to west across this site. At the *4-H Camp* site, based on 1852 measurements, for the 0 to 75 cm depth interval, EC_a averaged 11.5 mS/m with a range of 2.0 to 43.2 mS/m. For the 0 to 150 cm depth interval, EC_a averaged 23.2 mS/m with a range of 11.2 to 51.8 mS/m.

[7] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [04/28/2015].

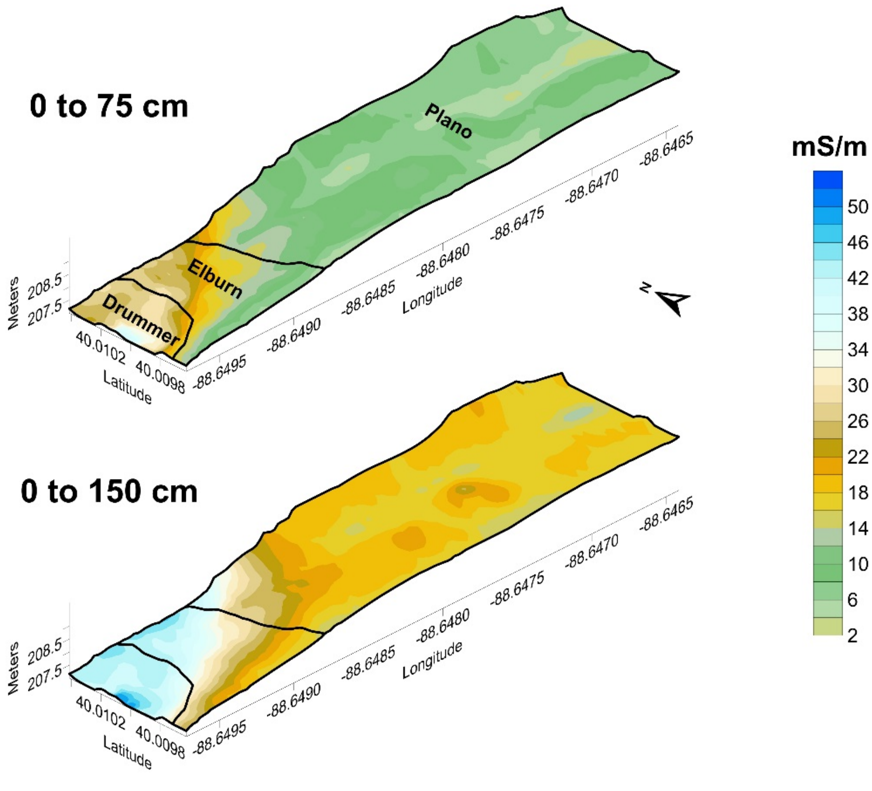

Figure 7. These 3D images show the distribution of EC_a measured across the 4-H Camp site in Piatt County for the upper 75 (top) and 150 (bottom) cm of the soil profiles. Soil boundary lines and soil names have been imported from the Web Soil Survey.

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