Spatially Variable Soil Salinity, Chemistry, and Physical Properties Affect Soil Health

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Abstract

Soil chemical properties as related to salinity and soil health are being investigated on a 65-ha agricultural field in southeastern North Dakota. The field historically has areas of low productivity as a result of salinity. The salinity is a result of evaporative deposition of salts from the shallow groundwater and is influenced by micro-topography. Yield maps indicate that the areas of low yield correspond very closely to areas of high bulk soil electrical conductivity (EC_b) mapped using a Veris 3100 EC Mapper. Soil cores taken on a 58-m grid indicated higher calcium, sodium, magnesium, and sodium adsorption ratio (SAR) in the upper 30 cm in areas of high salinity. The spatial extent of high concentrations of these ions increased with depth. Soil physical properties were measured on a 174-m grid. These data will be used to model unsaturated and saturated water flow. Research is ongoing to investigate the effects of subsurface drainage on soil salinity in the area.

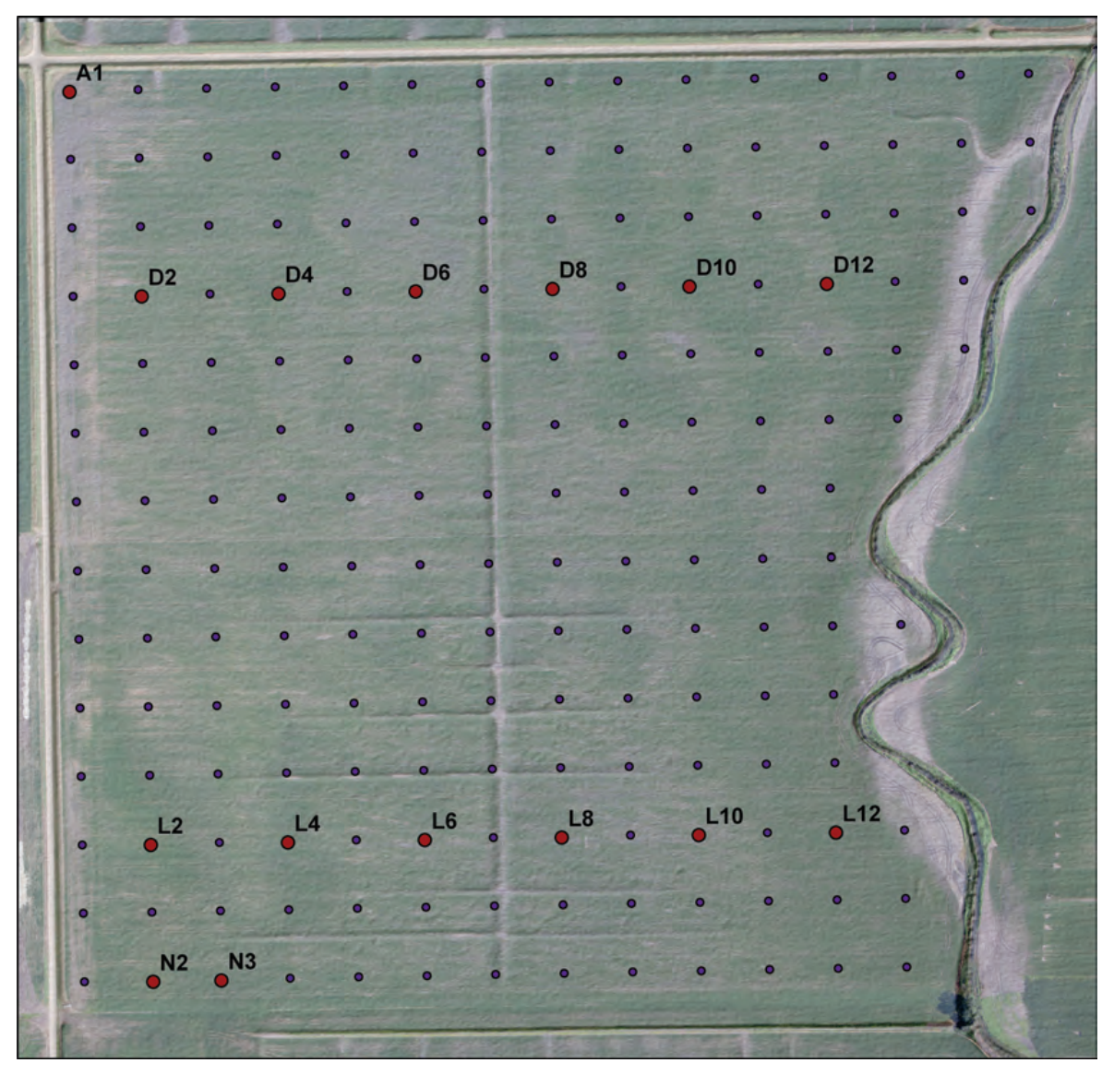

Figure 1. Aerial photo over topography shaded relief showing location of soil samples (blue) and groundwater monitoring wells (red).

Soil cores were taken on a 58-m grid (blue dots in Fig. 1) with a truck mounted hydraulic soil probe to a depth of 120 cm. All samples were analyzed for chemical constituents and samples from a 174-m grid were analyzed for physical properties as well. Groundwater monitoring wells were installed at 15 locations (red dots on Fig. 1) to a depth of 2.4 m and sampled periodically during the unfrozen months since Nov 2013.

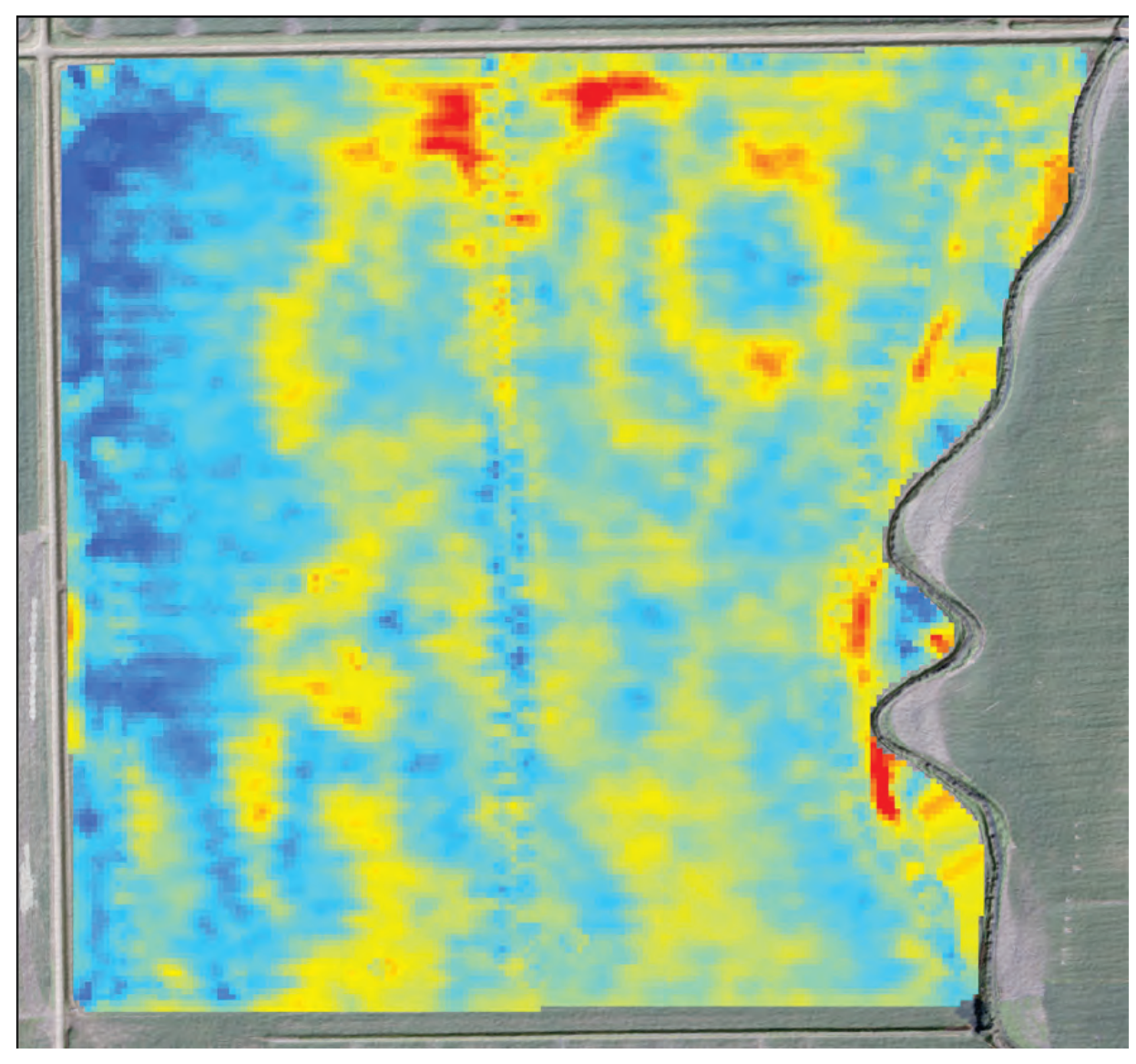

Figure 2. Soybean yield (kg ha^{-1}) measured via yield monitor in 2013.

Soybean yield was negatively affected by soil salinity. Note the similarity in patterns of low yield on the western side of the field (Fig. 2) compared to the pattern of high soil EC, especially the deep EC, in the same area (Fig 3).

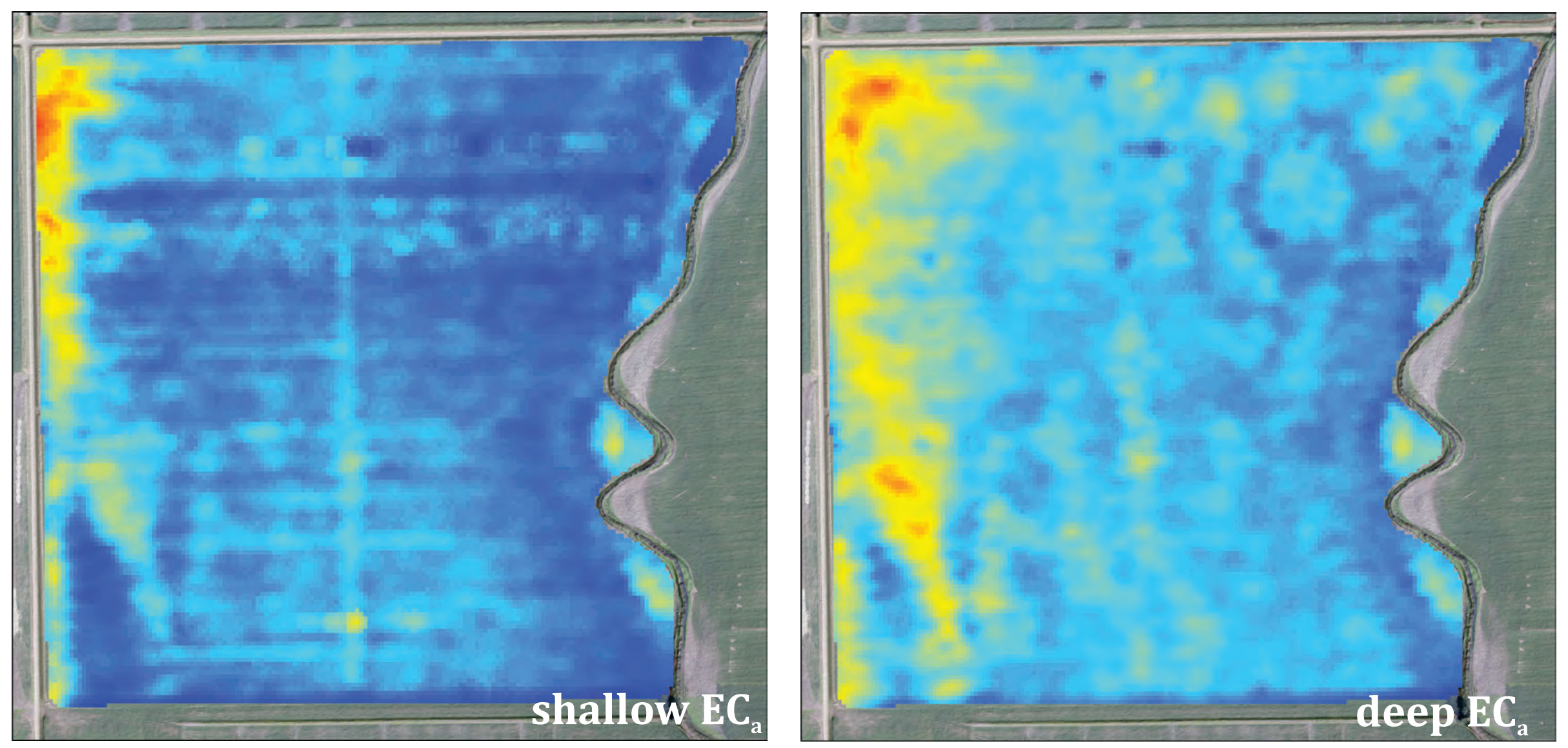

Figure 3. Shallow and deep bulk soil EC_b (mS cm^{-1}) measured via Veris 3100 mapper after 2013 harvest. Shallow represents 0-30 cm depth and deep represents 0-90 cm. Values were adjusted from raw Veris readings to 1:1 EC using calibration soil cores.

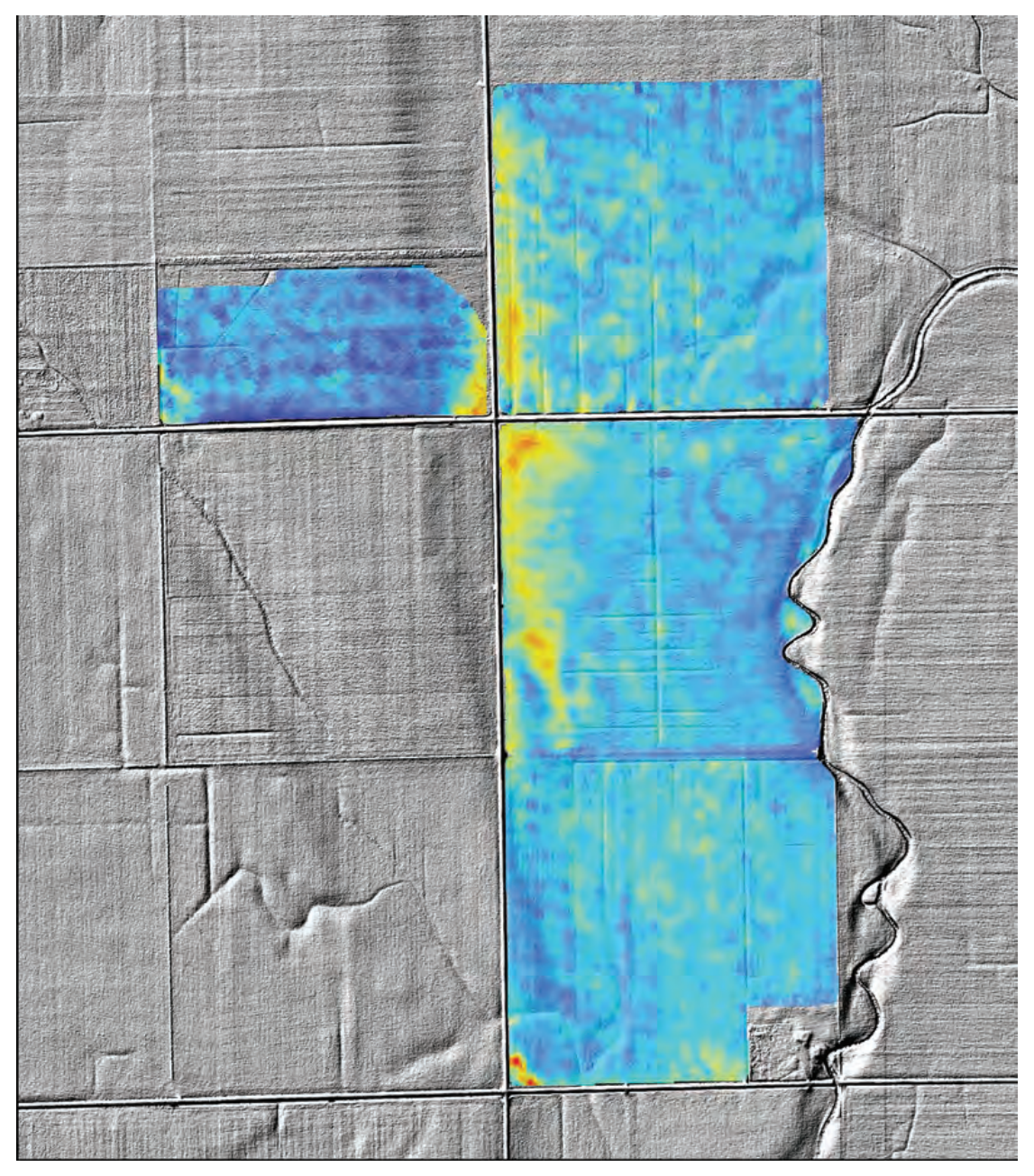

Figure 4. Deep bulk soil EC at the study field and three surrounding fields draped over topography shaded relief.

Note the continuation of the pattern of high EC in the surrounding fields. Lower topography at the study site compared to fields to west result in closer proximity of groundwater to soil surface. Salts are hence able to migrate via capillarity from the water table to the crop root zone, negatively impacting yield (Fig. 2).

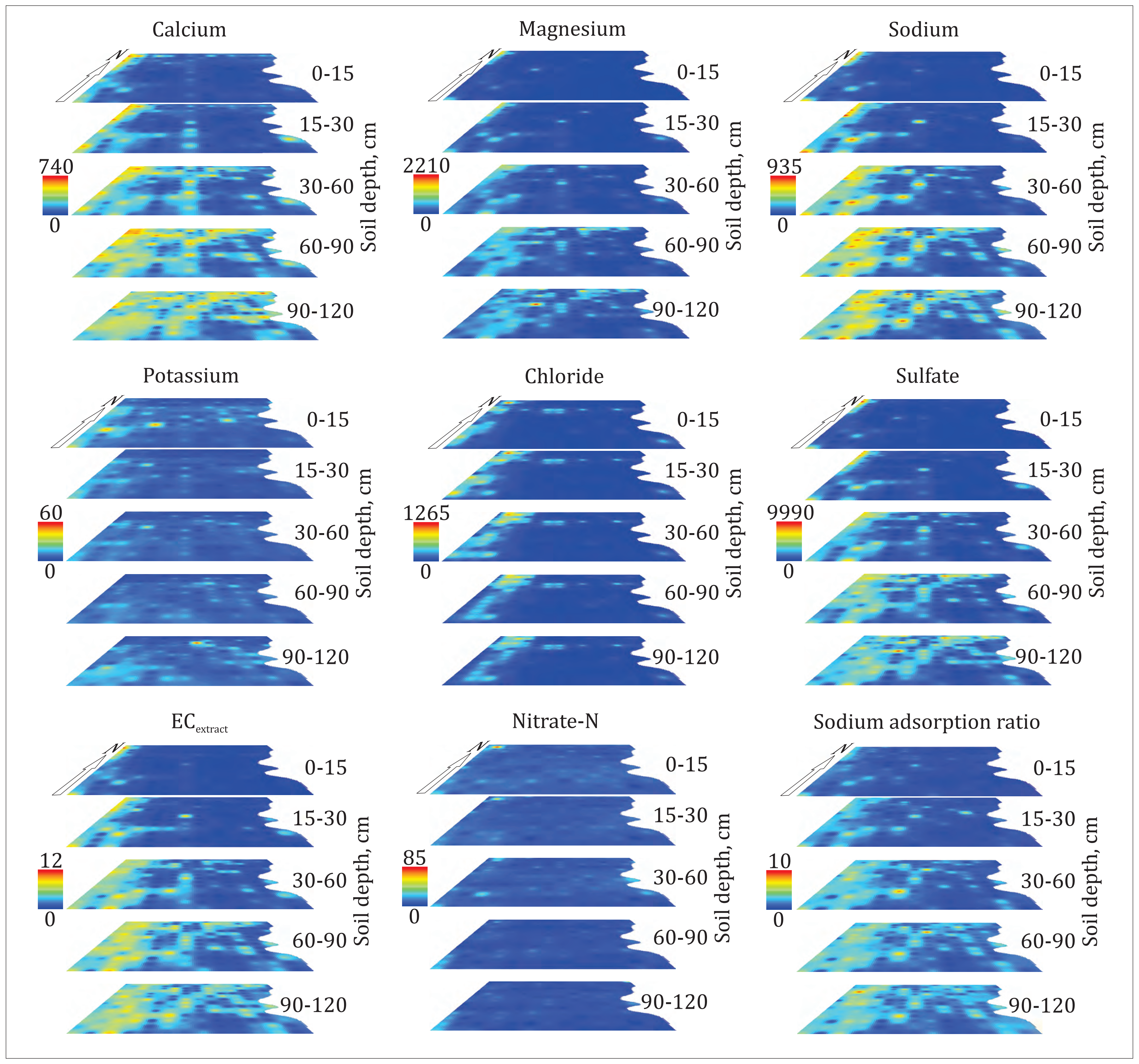

Figure 5. Perspective view maps of concentrations (mg L^{-1}) and EC (mS cm^{-1})of chemical constituents in saturated paste extracts of soil samples taken at the 186 58-m grid point locations at 5 depths.

Higher concentrations of ions were measured at lower depths across much of the field and in the northwest area of the field at the surface depths. The salts from lower depths can move up with the groundwater to near the soil surface in areas of lower topography.

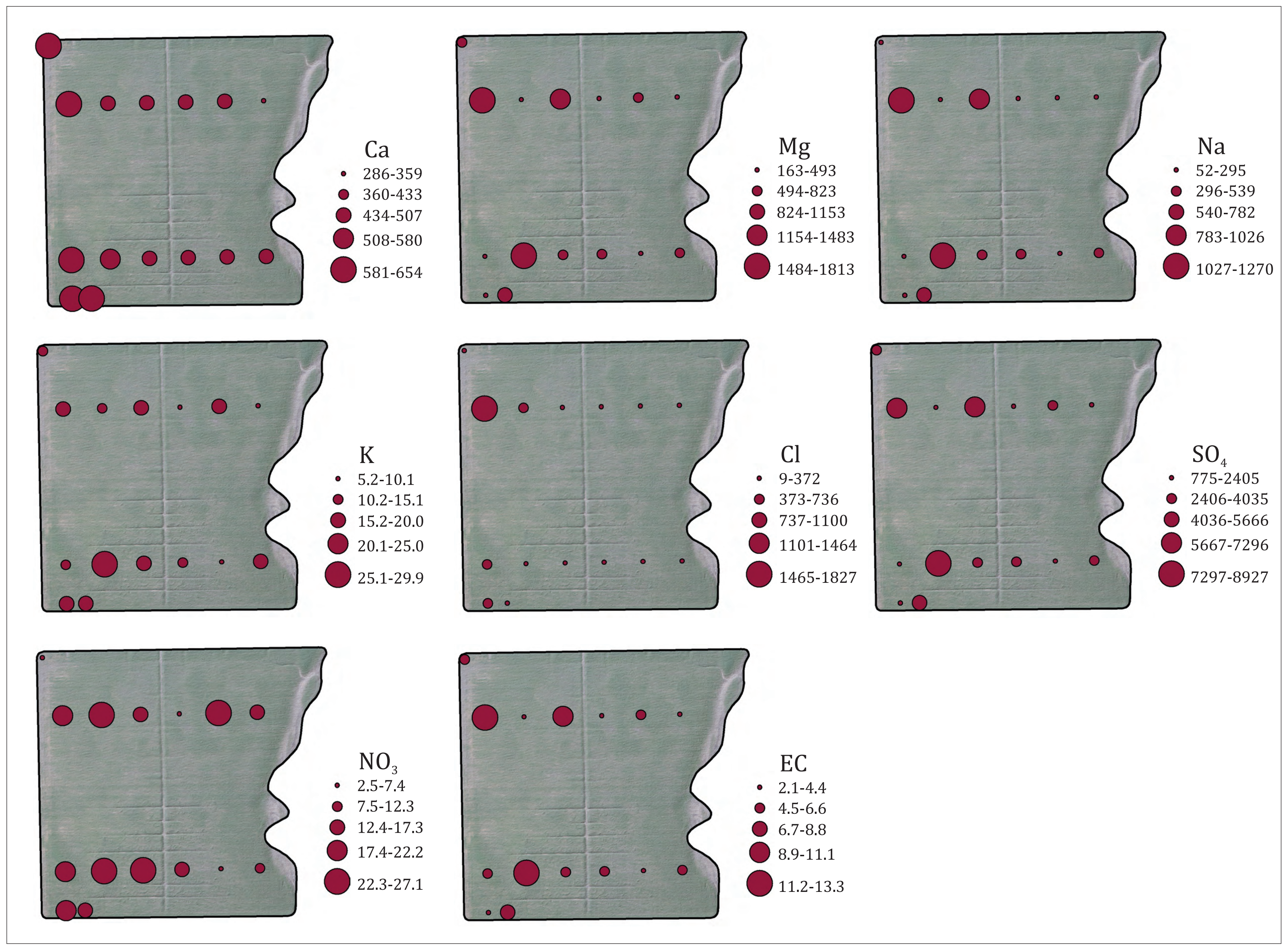

Figure 6. Average chemical constituent concentrations (mg L^{-1}) and EC (mS cm^{-1}) of the groundwater measured at the 15 monitoring wells. The size of the dots are relative to the concentration.

Similar to the soil ion concentrations at the deeper depths (Fig. 5), the groundwater concentrations are higher in the western portion of the field. This is an indication that the soil salinity is linked to groundwater chemistry.

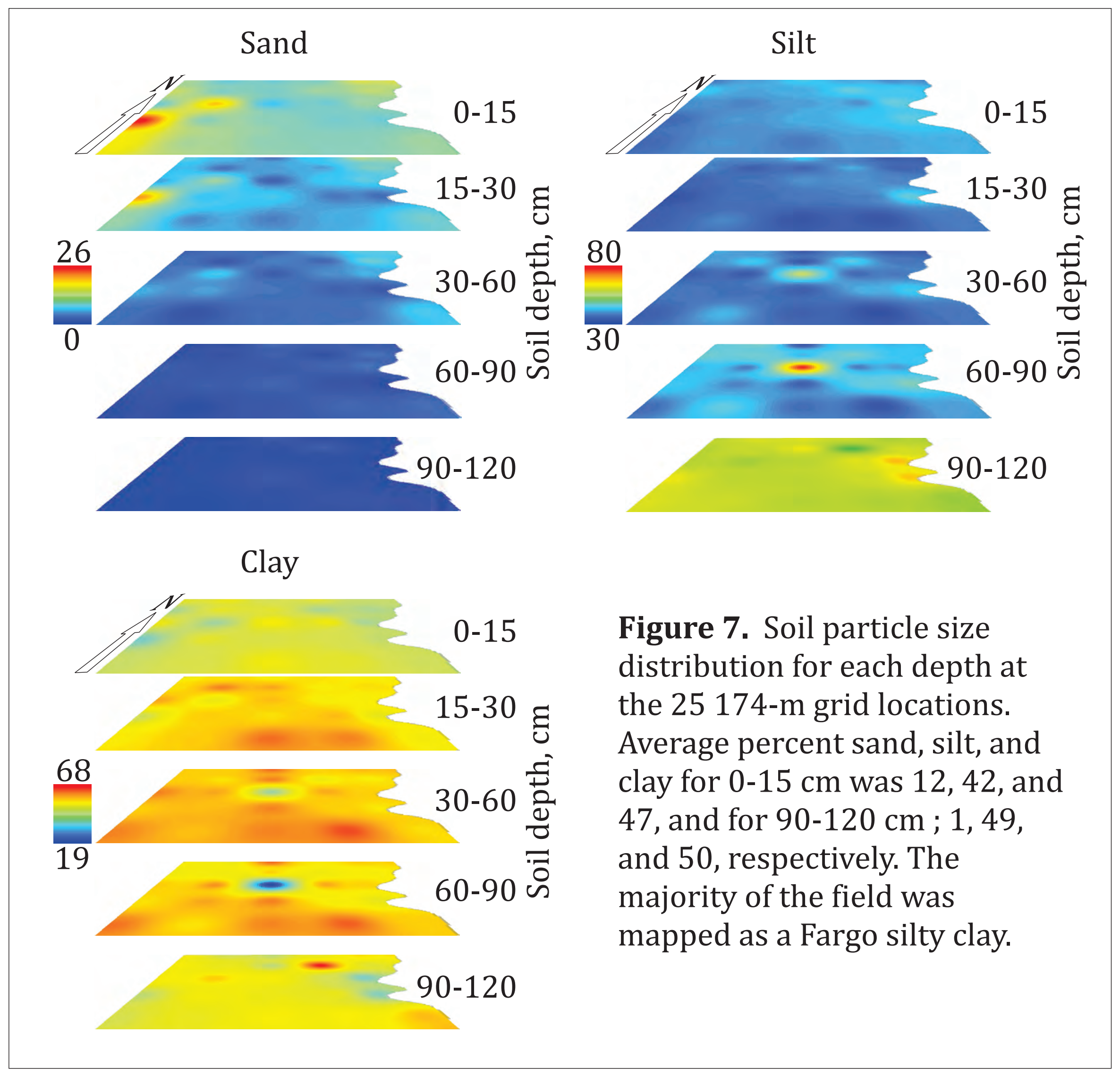

Figure 7. Soil particle size distribution for each depth at the 25 174-m grid locations. Average percent sand, silt, and clay for 0-15 cm was 12, 42, and 47, and for 90-120 cm ; 1, 49, and 50, respectively. The majority of the field was mapped as a Fargo silty clay.

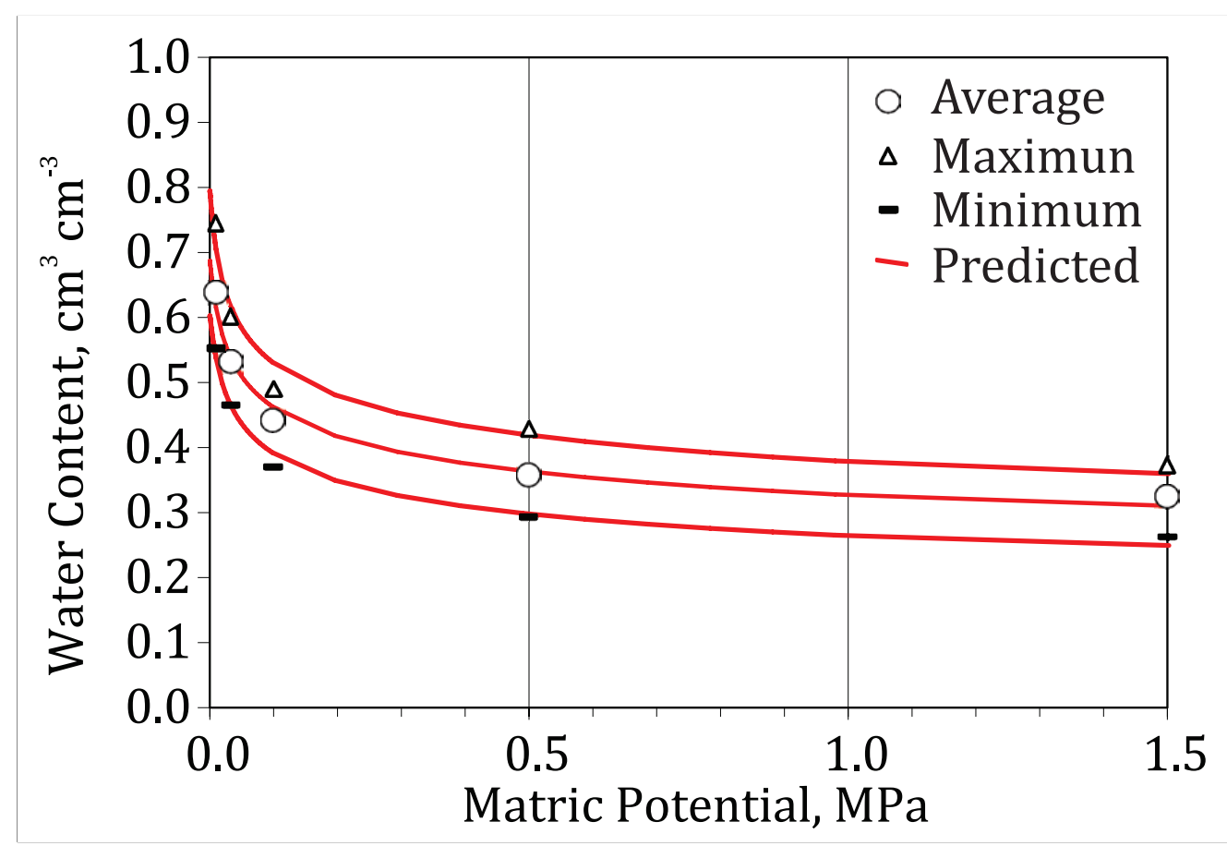

Figure 8. Water release curves for select soil samples.

Soil water release curves were constructed for five depths at each of the 25 174-m grid locations. The chart shows the field average and the range of curves for all locations. The van Genuchten equation was used to fit the measured water content data. This data will be used to model water movement through the root zone and subsurface drainage system.

Figure 9. Aerial photo showing disturbance where subsurface drains were installed.

Subsurface drains were installed on the north half of the field in the summer of 2014. The drains are 1.2 m deep and spaced 12 m apart. This will allow comparison of crop response and soil health parameters between saline/non-saline and drained/undrained conditions.

Salts in the soil may be reduced if leached and then removed through the drains. The drains will also aid in keeping the water table lower to reduce capillary movement of water and salts to the soil surface.

Summary

The field was intensively soil sampled on a 58-m grid to 120 cm deep and groundwater monitoring wells were installed. Yield was mapped with a yield monitor-equipped combine and soil bulk EC was mapped with a Veris EC mapper. Patterns emerged in the mapped data indicating spatially variable distribution of soil and groundwater salts. Soybean yield was also spatially variable and was negatively impacted by saline soil conditions. Rising water tables due to a 20 y wet climatic cycle continue to move salts into the crop root zone. Farming practices will need to be modified in order to remediate or sustain the productivity of the soil in these areas. Subsurface drainage is being used in an attempt to remove salts from the root zone by removing deep percolation and keeping the water table lower to reduce evaporative deposition. Planting salt tolerant crops in saline areas may also be necessary. Producers and researchers will use information collected at this site to recommend practices to reduce the impact of saline soils.

Acknowledgments

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- Ken Johnson Farms.

References

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