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PV-SuCCESS Soil Data Collection Plan

Objective

The Photovoltaics Supporting Cultural and Community EcoSystem Services (PV-SuCCESS) project is a collaboration between the Great Plains Institute, University of Minnesota, Argonne National Laboratory, the Midwest Tribal Energy Resources Association, and the Minnesota Clean Energy Resources Teams. Soil data collection is being led by Dr. David Mulla in collaboration with Jake Galzki, both from the University of Minnesota, Department of Soil, Water, and Climate. PV-SuCCESS field data collection is intended to provide a detailed assessment of physical, chemical, and biological soil characteristics present at solar power generating farms and how these data can help inform a decision-support framework for ecosystem services.

Research Study Area

The current study area consists of six solar farms, five of which are in Minnesota, and the sixth is in New York (Fig. 1). Minnesota sites are located near the cities of Atwater, Becker, Chisago, Mankato, and Ramsey. The sixth site is located near Ithaca, NY. All sites will be instrumented for continuous soil moisture measurements at select point locations, and stratified grid sampling will be performed to analyze biological and chemical soil properties. Sites will be sampled and monitored for a duration of three years.

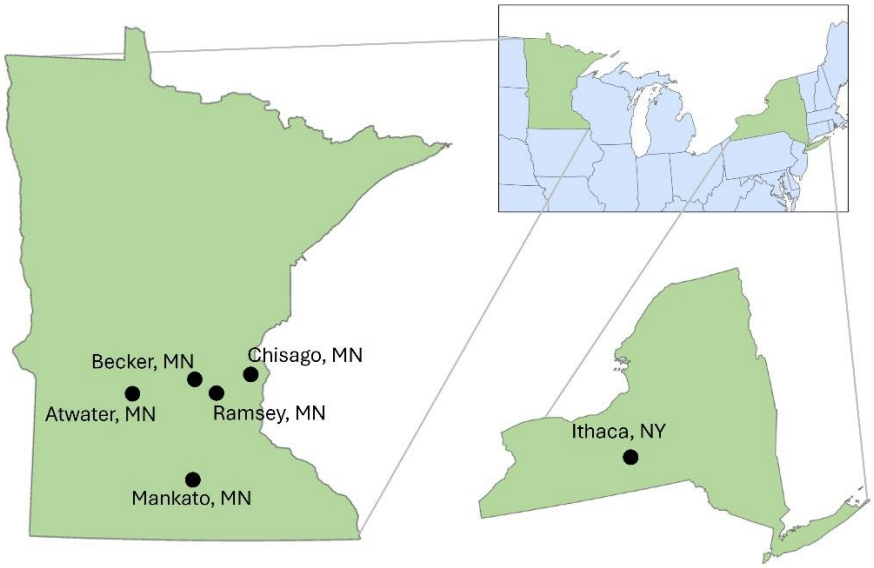


Figure 1. Location of study sites distributed across Minnesota and New York

Soil Moisture Instrumentation

Continuous soil moisture measurements will be taken at select point locations at each research study site at 15-minute intervals for the duration of the project. An array of soil moisture probes will be installed to analyze the hydrologic relationship of three main locations within a solar farm: underneath panels, where runoff is concentrated at the panel edge, and the area between the panels referred to here as the full sun area. This arrangement will attempt to analyze the complex hydrologic response unique to this type of system. Moisture measurements will be used to inform and validate a model developed from the Photovoltaic Stormwater Management Research and Testing (PV-SMaRT) project (Mulla et al., 2024). Two replicates of soil moisture probe arrays will be used per site, one of which will also measure ambient precipitation. If fixed panels are present, a drip edge rain gauge will also be installed to quantify the relationship between ambient precipitation and drip edge runoff. An example of the soil moisture probe replicates can be seen in Fig. 2.

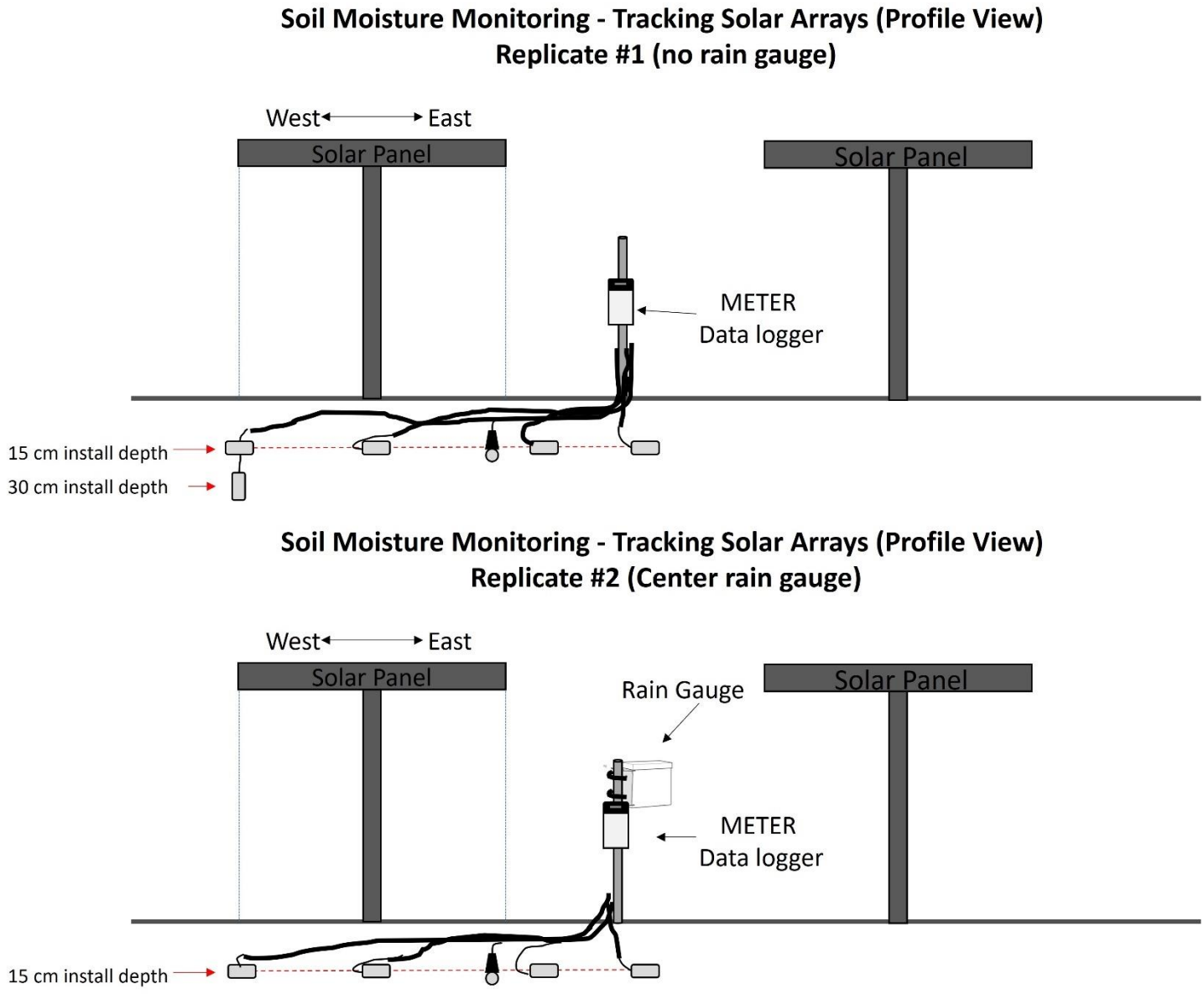


Figure 2. A diagram of the locations of soil moisture monitoring equipment and its relation to solar panels

Additional measurements at point locations

Additional measurements will be taken at each soil moisture monitoring replicate to further inform and validate soil moisture modeling including soil texture (hydrometer method), soil bulk density (Uhland sampler method), and infiltration

measurements (Cornell Sprinkle Infiltrometer method). These additional physical soil measurements will be taken to further assess hydrologic impacts at the three soil moisture probe locations (under panel, under drip edge, and in full sun).

Stratified Biological and Chemical Soil Sampling

To quantify the biological and chemical composition of soils, stratified soil samples will be acquired at all research locations. A soil sample density of 2 samples per acre will be employed for all constituents except Total Phosphorus. To keep sampling costs reasonable, density of Total Phosphorus samples will be reduced to 1 sample per acre. For larger sites with relatively homogenous soils, a representative sampling area will be identified to keep sampling requirements within budget constraints. Samples will be stratified by local SSURGO soil map units obtained from the web-soil survey (USDA–NRCS, 2019). Samples will be divided equally between the full sun area between solar panels and the area directly underneath solar panels to analyze any relationship present. All biological and chemical constituents will be sampled at a depth of 0-15 cm; Nitrate-N will be sampled at the additional depth of 15-30 cm to analyze N mobility in the soil profile. Six grab samples will be collected within a 1 m^2 sampling area and mixed to make a composite sample. Sampling will take place for three years; all constituents will be sampled in year 1, and a schedule of remaining sampling will focus on parameters with a higher likelihood to change over time. Table 1 summarizes the schedule of sampling parameters for each research site. Some of the research sites also contain specific areas with different treatments present (ex. Newly seeded perennial vegetation, different sheep grazing densities, etc.); sampling points will be focused in treatment areas to analyze potential differences in ecosystem services caused by these treatments.

			Sampling Schedule		
Soil Sampling Parameter	Sampling Density	Sampling Depth (cm)	Year 1	Year 2	Year 3
Organic Matter	2 samples/acre	0-15	X	X	X
pH	2 samples/acre	0-15	X	X	X
Nitrate-N	2 samples/acre	0-15, 15-30	X	X	X
Total Phosphorus	1 sample/acre	0-15	X		
Plant Available Phosphorus	2 samples/acre	0-15	X	X	X
Potassium	2 samples/acre	0-15	X	X	X
Total Organic Carbon	2 samples/acre	0-15	X		X
Electrical Conductance	3 samples/acre	0-15	X		X

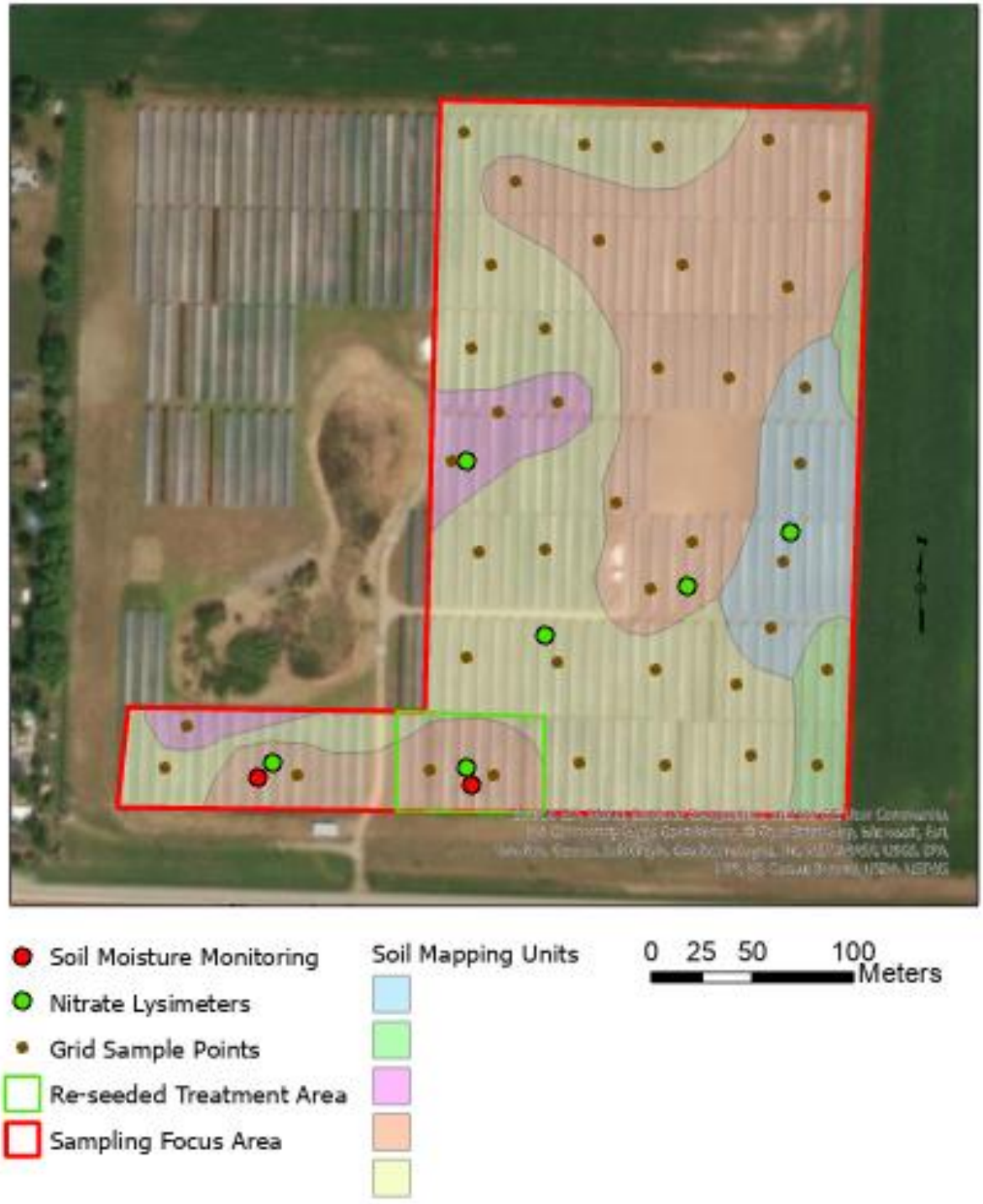
Table 1. Soil sampling parameters and their respective sampling schedule over the 3-year study period

Lysimeter Leachate Sampling

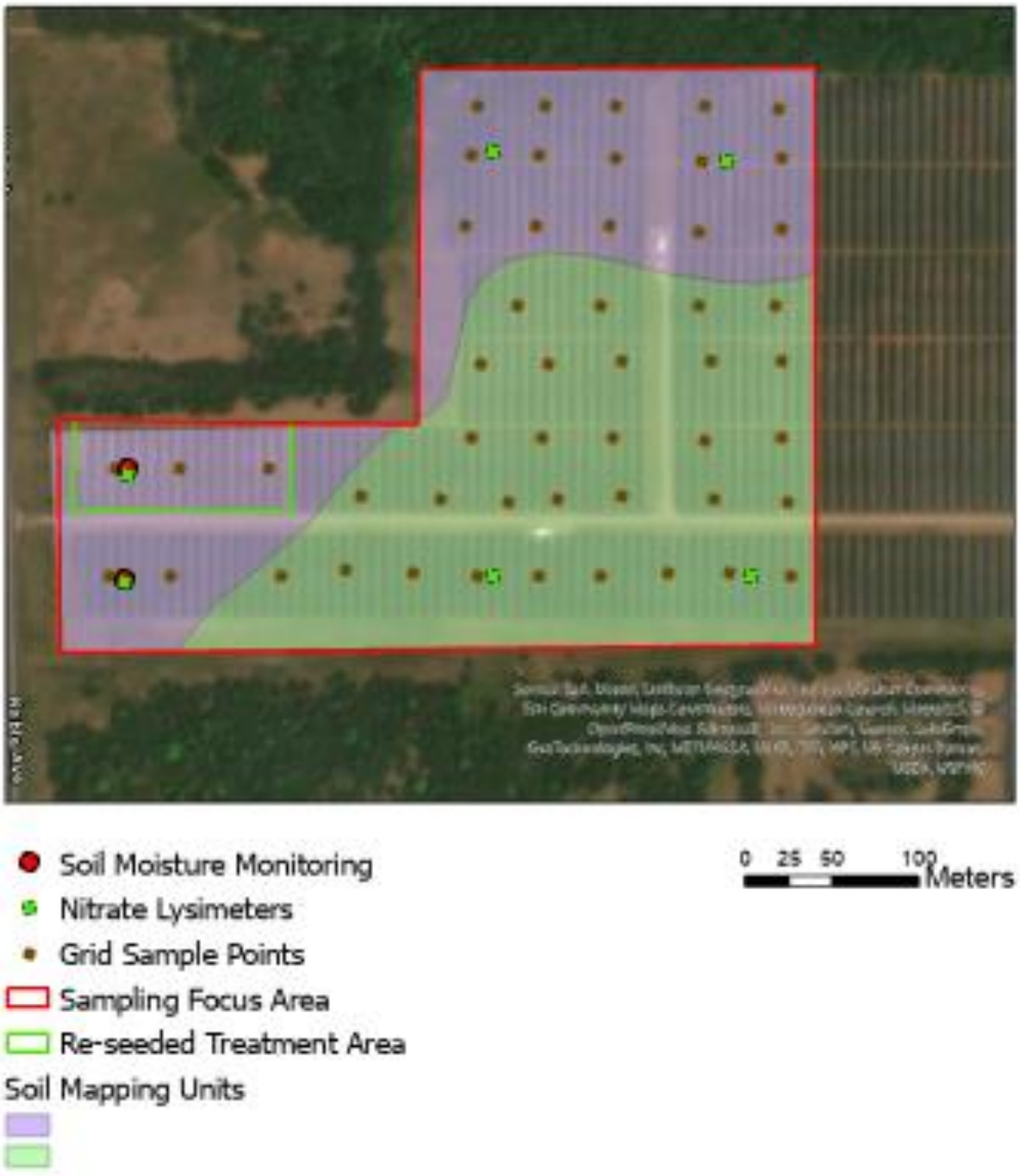
Suction lysimeters will be installed at 6 locations distributed throughout each research site. These will be installed to collect leachate water samples at a depth of 30 cm. Leachate will be collected 6 times during the frost-free season and analyzed for Nitrate-N. It is not feasible to travel to the New York site shortly after a precipitation event nor is it feasible to travel there multiple times per summer; therefore, lysimeters will not be installed at the New York site.

Sampling Strategy at Each Site

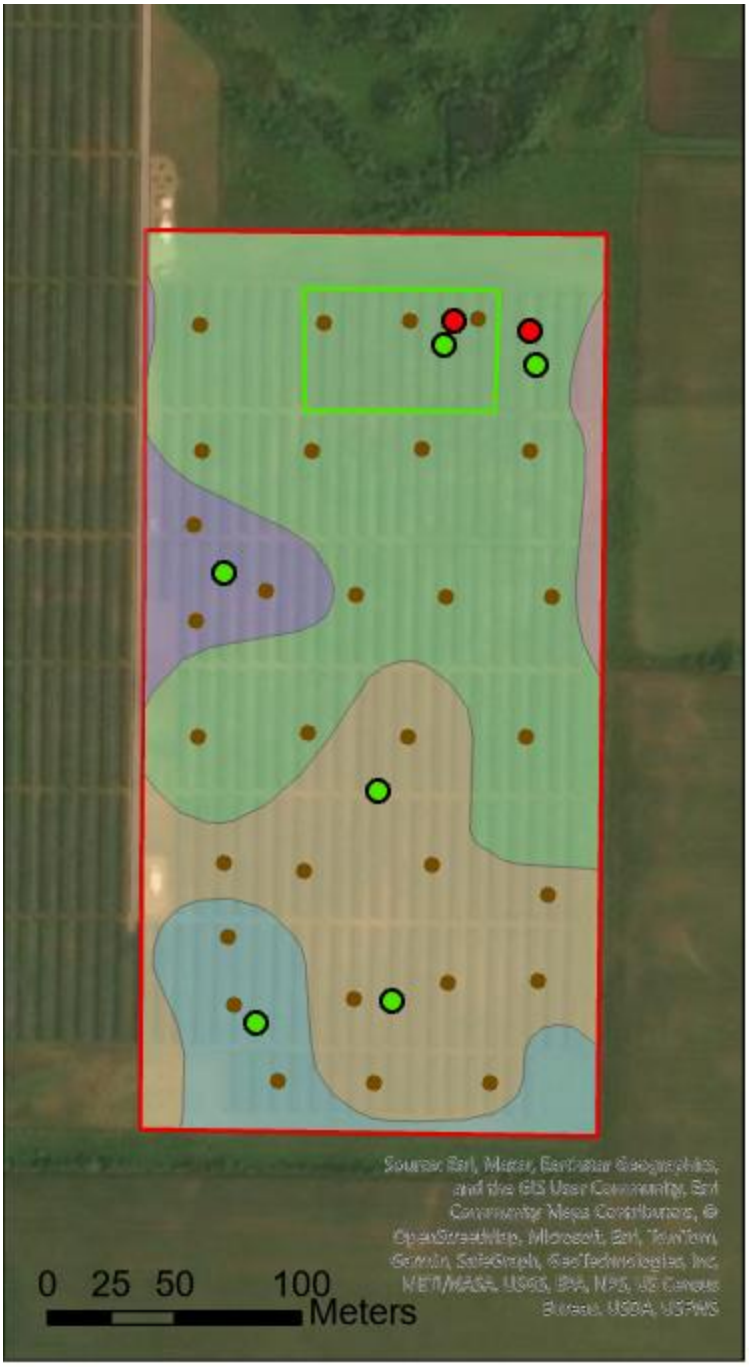
Atwater, MN



Chisago, MN

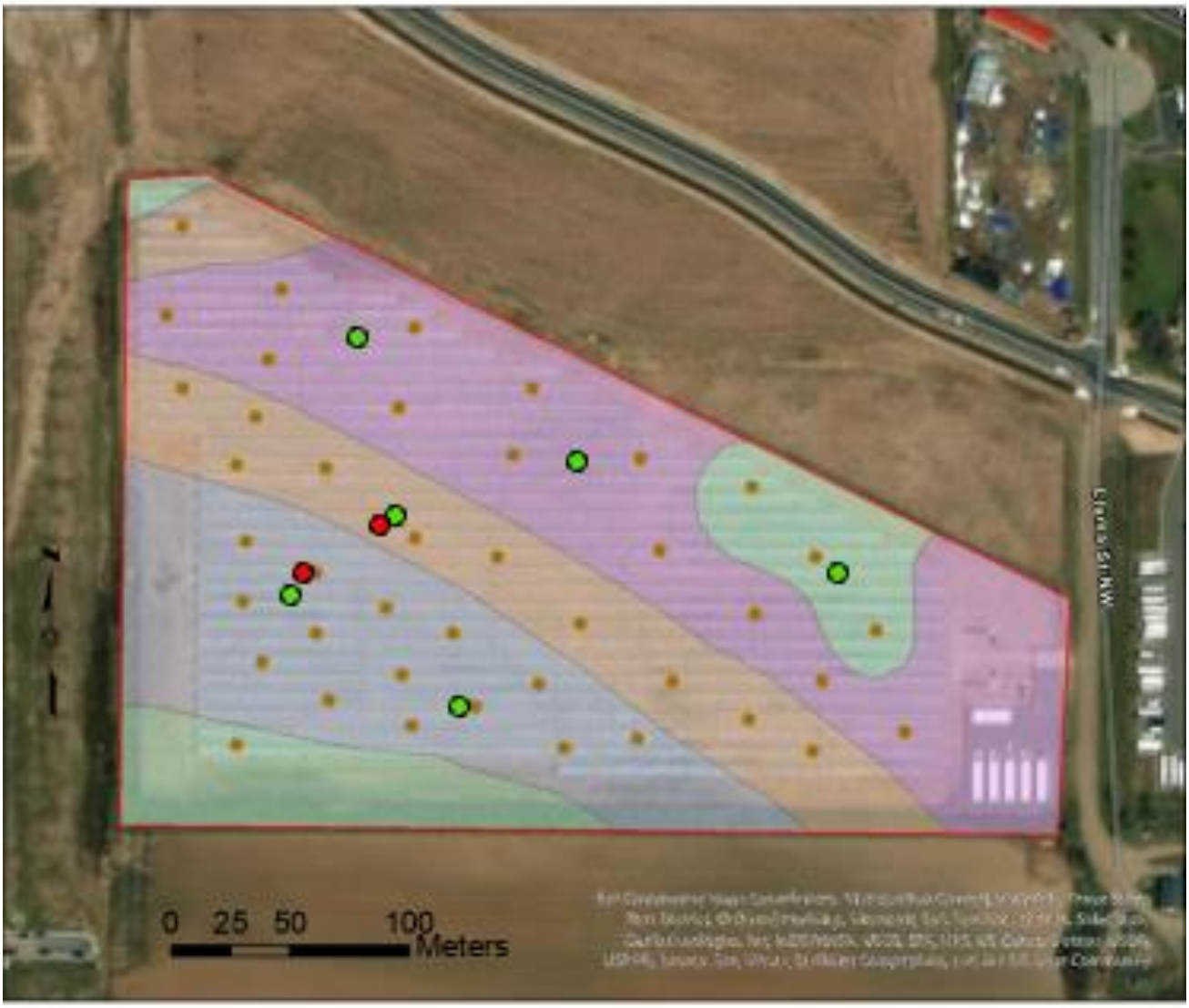

Soil Moisture Monitoring
Nitrate Lysimeters
Grid Sample Points
Sampling Focus Area
Re-seeded Treatment Area
Soil Mapping Units
0 25 50 100
Meters

Mankato, MN



Nitrate Lysimeters
Soil Moisture Monitoring
Grid Sample Points
Re-seeded Treatment Area
Sampling Focus Area
Soil Mapping Units

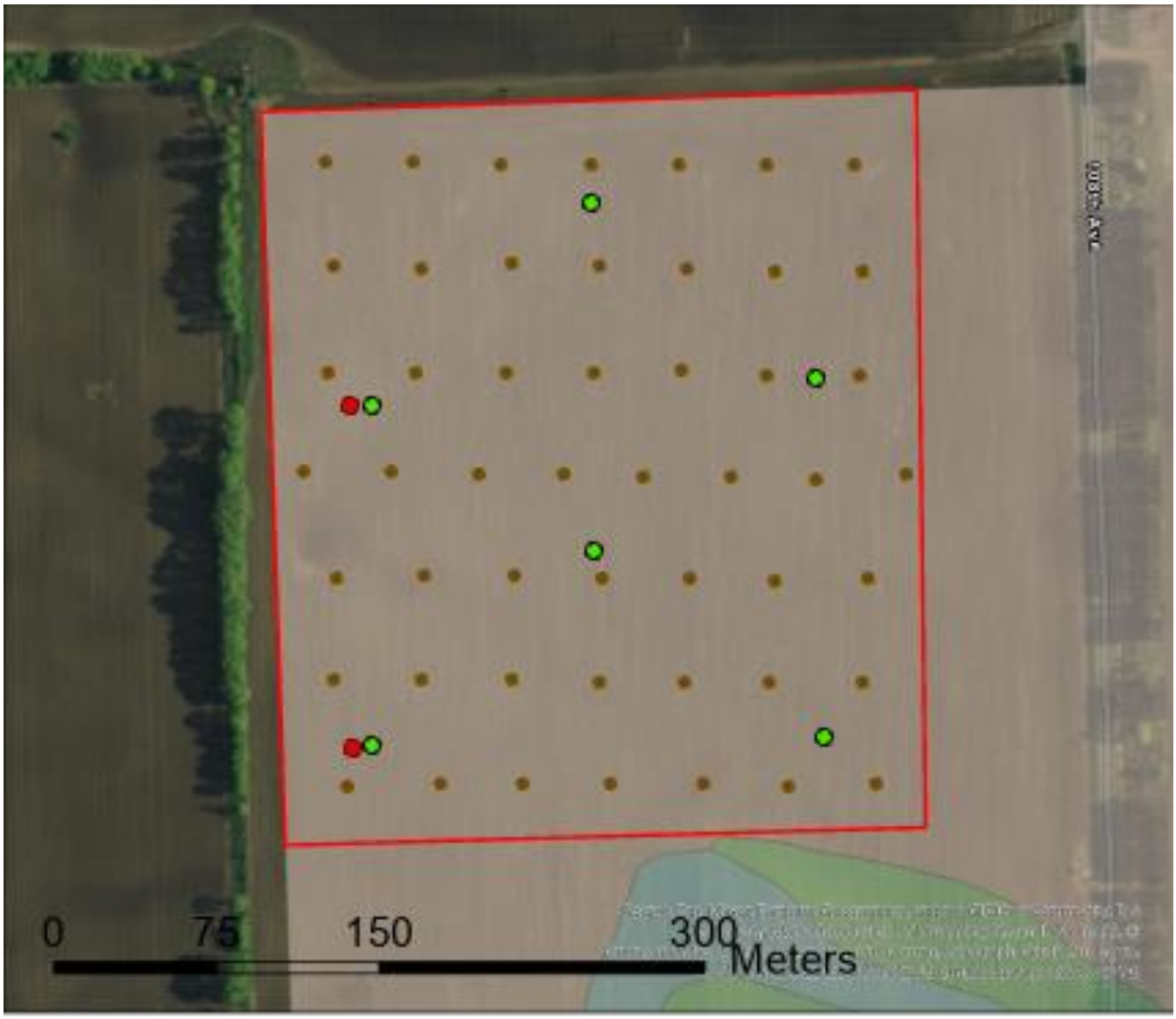
Ramsey, MN



- Soil Moisture Monitoring
- Nitrate Lysimeters
- Grid Sampling Points
- Sampling Focus Area

Soil Mapping Units

Becker, MN



- Nitrate Lysimeters
- Grid Sample Points
- Soil Moisture Monitoring
- Sampling Focus Area

Soil Map Units

Ithaca, NY


Soil Moisture Monitoring
Grid Sample Points
Sampling Focus Area
Grazing Treatment Areas
Soil Mapping Units
N
0 25 50 100
Meters

References

Mulla, D., Galzki, J., Hanson, A., & Simunek, J. (2024). Measuring and modeling soil moisture and runoff at solar farms using a disconnected impervious surface approach. *Vadose Zone Journal*, e20335.

USDA-NRCS (2019). Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available at: https://websoilsurvey.nrcs.usda.gov/app/